

NATIONAL GEOGRAPHIC



Healing the Heart

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Hawaii's Unearthly Worms 118 Forests of the Tide 132

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Roshini Thinakaran looks at war through the eyes of women, documenting personal struggles to survive conflict, rebuild lives, and restore nations.



ENVIRONMENTAL CRUSADER & ADVENTURER

David de Rothschild uses his extreme expeditions and the Internet to inspire environmental awareness among schoolchildren.

CONSERVATION SCIENTIST

Conservation scientist **Dr. Luke Dollar** fights to save animals endangered by predators, preserve threatened habitats, and create new opportunities for the people of Madagascar.



MUSICAL EXPLORER & FILMMAKER

Joshua Ponté works to save unique species, habitat, and cultural traditions on the brink of extinction in Gabon.



HUMANITARIAN

John Bui Dau, who made a death-defying escape from Sudan (featured in the documentary "God Grew Tired of Us"), champions human rights and is working to create a health clinic in his home area.



BOTANIST & ENVIRONMENTAL HERO

Corneille Ewango risked his life to protect the forests and people of the Okapi Faunal Reserve during Congo's brutal civil war.

MARINE ECOLOGIST & CONSERVATION BIOLOGIST

Dr. Enric Sala explores the seas to gauge human impact, guide conservation, and create a healthier future for the world's coastal ecosystems.



PRIMATOLOGIST & CONSERVATIONIST

Mireya Mayor uses conservation fieldwork and the power of television to shed light on the world's most endangered species and places.



NATIONAL GEOGRAPHIC

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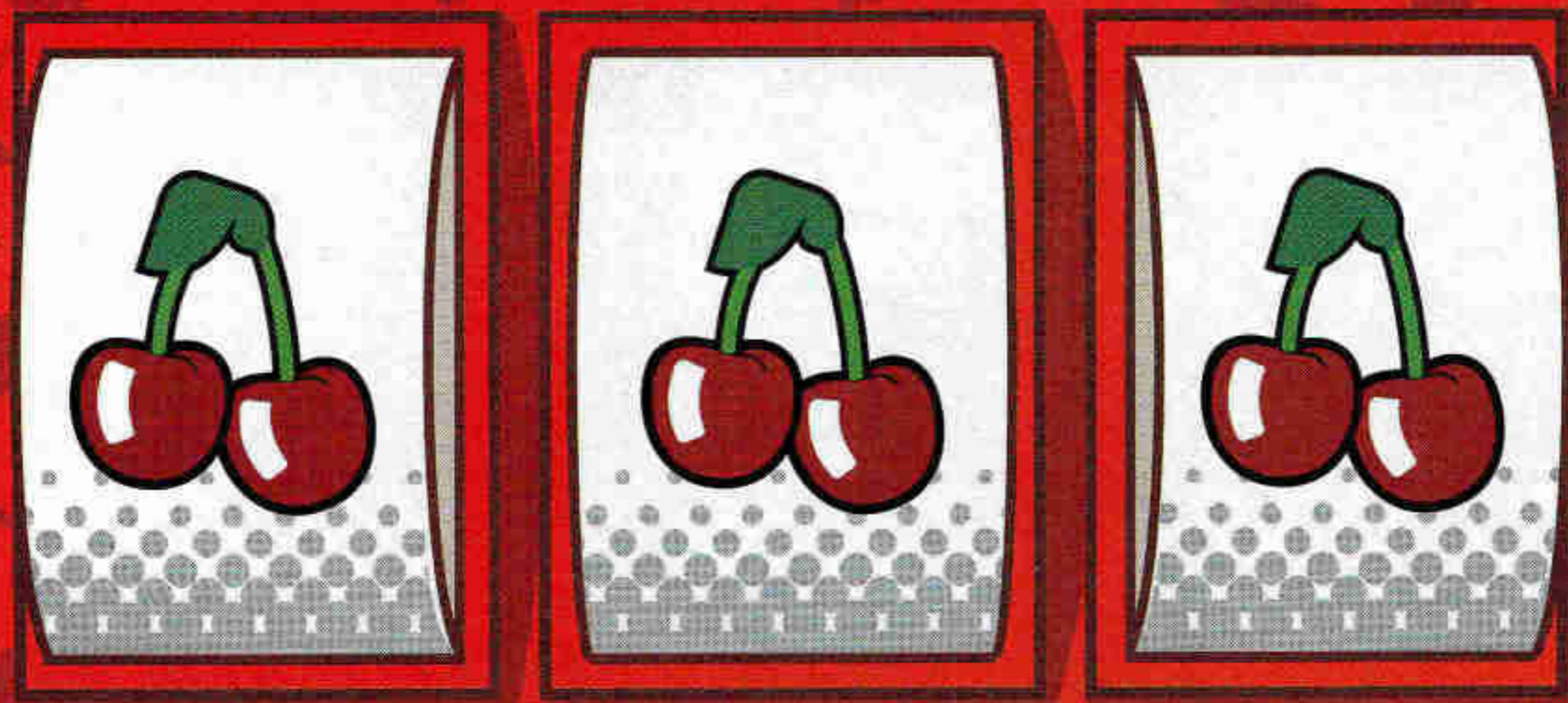
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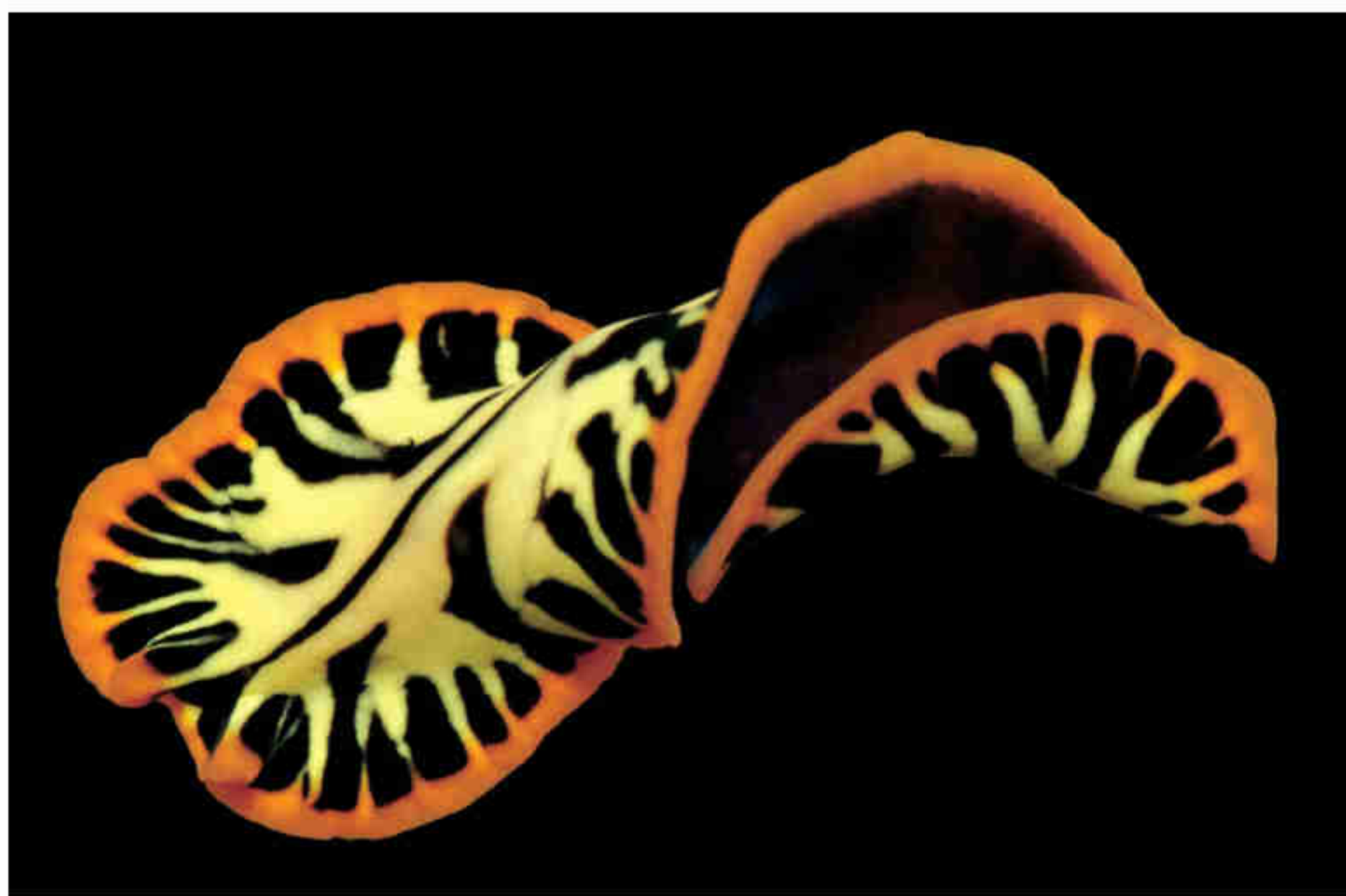
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FEBRUARY 2007 • VOL. 211 • NO. 2

This toxic flatworm's vivid markings spell danger to potential predators along Hawaii's coral reefs. Story on page 118.



DARLYNE A. MURAWSKI

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- Healing the Heart** 40 As heart disease reaches epidemic proportions worldwide, researchers are moving away from the old “clogged-pipes” model to search for triggers lurking in our genes.
BY JENNIFER KAHN PHOTOGRAPHS BY ROBERT CLARK
- Desolate Majesty** 66 Straddling Texas and Mexico, the Big Bend region is high in biodiversity and low in footprints. It's a place so untamed that if something doesn't bite, stick, or sting, it's probably a rock.
BY JOE NICK PATOSKI PHOTOGRAPHS BY JACK W. DYKINGA
- Curse of the Black Gold** 88 The Niger Delta holds some of the world's richest oil deposits, yet Nigerians living there are poorer than ever, violence is rampant, and the land and water are fouled. What went wrong?
BY TOM O'NEILL PHOTOGRAPHS BY ED KASHI
- Hawaii's Unearthly Worms** 118 Lowly marine worms ply shallow shores, ocean deeps, and just about everywhere in between. Off the Hawaiian Islands, they assume spectacular forms.
BY JENNIFER S. HOLLAND PHOTOGRAPHS BY DARLYNE A. MURAWSKI
- Forests of the Tide** 132 At the intersection of land and sea, mangrove forests support a wealth of life, from starfish to people, and may be more important to the health of the planet than we ever realized.
BY KENNEDY WARNE PHOTOGRAPHS BY TIM LAMAN

COVER The intricacies of a human heart are revealed at the Mutter Museum in Philadelphia. **PHOTO BY ROBERT CLARK**

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OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY



Carnival



Street Food



Salar de Uyuni, Bolivia

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Healing Hearts

Witness groundbreaking heart-implant surgery through Robert Clark's time-lapse photography.

Blood and Oil

Hear the voices of people in the Niger Delta, where oil means riches for a few and poverty and suffering for many.

Wild Wigglers

Get close to bizarre marine worms in an otherworldly video.

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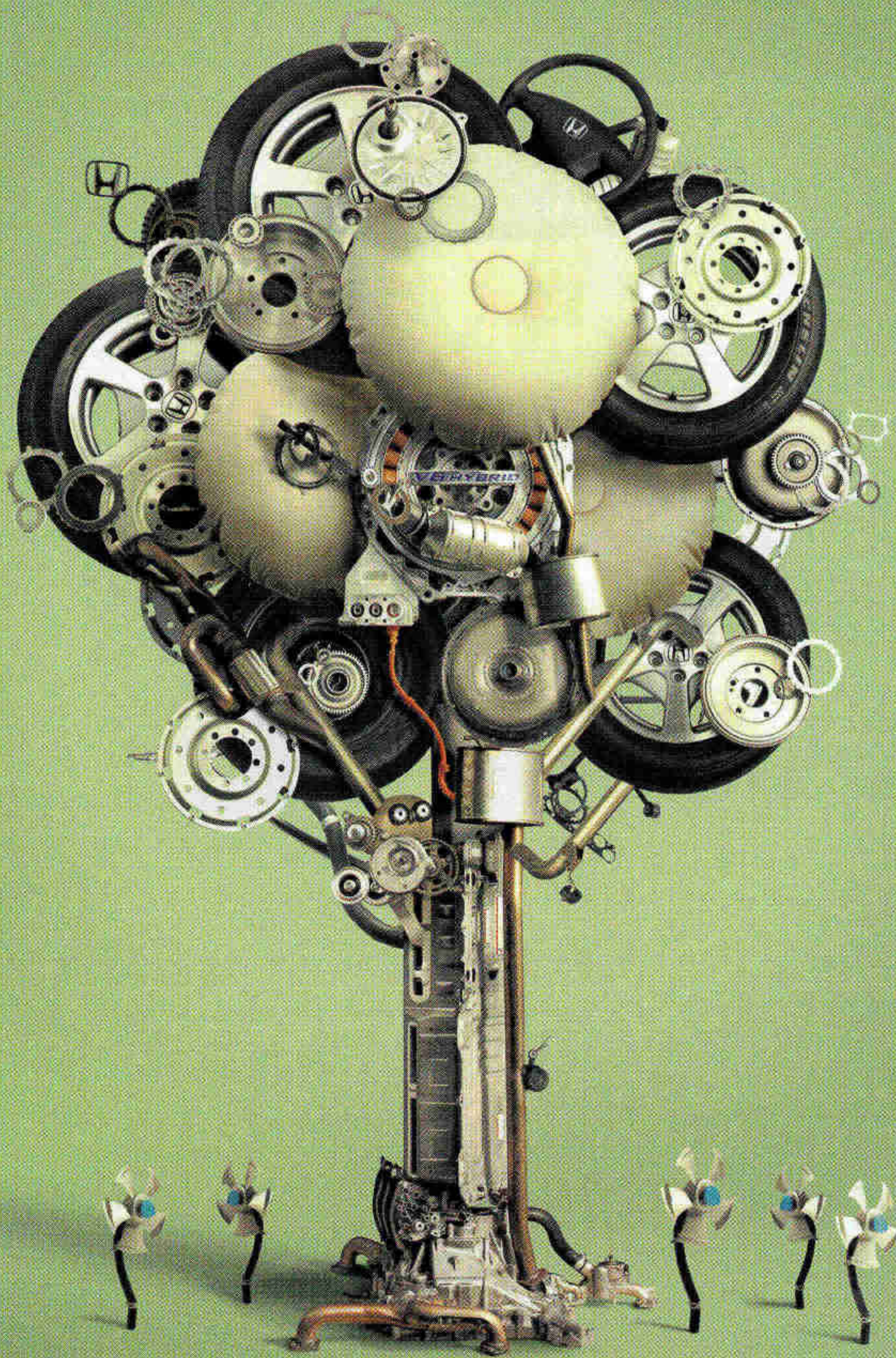
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At 17, Joanne Harriet Utz was a cheerleader for Medford High School in Medford, Oregon. The smiling girl who would grow up to be Editor Chris Johns's mother lived a lifetime of healthy habits—but she was still not protected from heart disease.

What you don't know can hurt you. When my 70-year-old mother waded into a swimming pool for a water aerobics class, she didn't know she was at risk for a heart attack. Halfway through the class she became short of breath, but continued exercising before driving home to tell my father that something was terribly wrong. He barely got her to the emergency room in time. She recovered, but suffered permanent damage to her heart.

My mother was a model of healthy living. She never smoked. She exercised, ate properly, kept her weight down and her blood pressure under control. She looked and felt great—which is why her heart attack shocked us all. My mother's experience was not unique. Heart disease is the leading cause of death among American women; it's also tougher to diagnose in women than in men.

Mom suffered her heart attack on my 45th birthday. I'm 55 now. Though I live a healthy life, I wonder if I've inherited her predisposition to the disease. A doctor told Jennifer Kahn, author of this month's cover story, that a person's coronary risk is "50 percent genetic and 50 percent cheeseburger."

I still indulge in cheeseburgers, but not as much. I want to give my heart all the help I can. I also want to share what we are learning about the heart, so you can know what can hurt you—and what you can do about it.



PHOTO: GLENN H. UTZ

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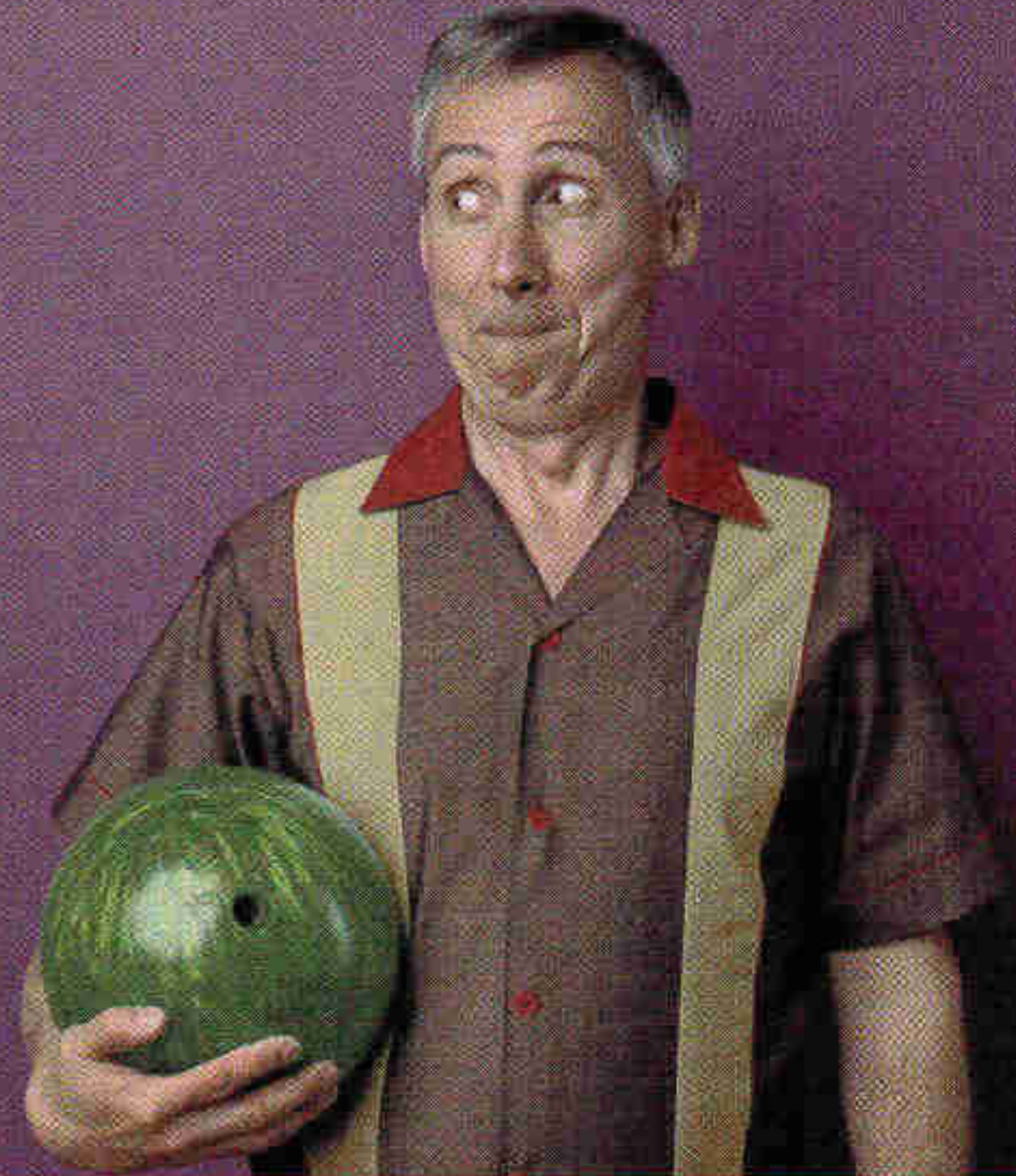
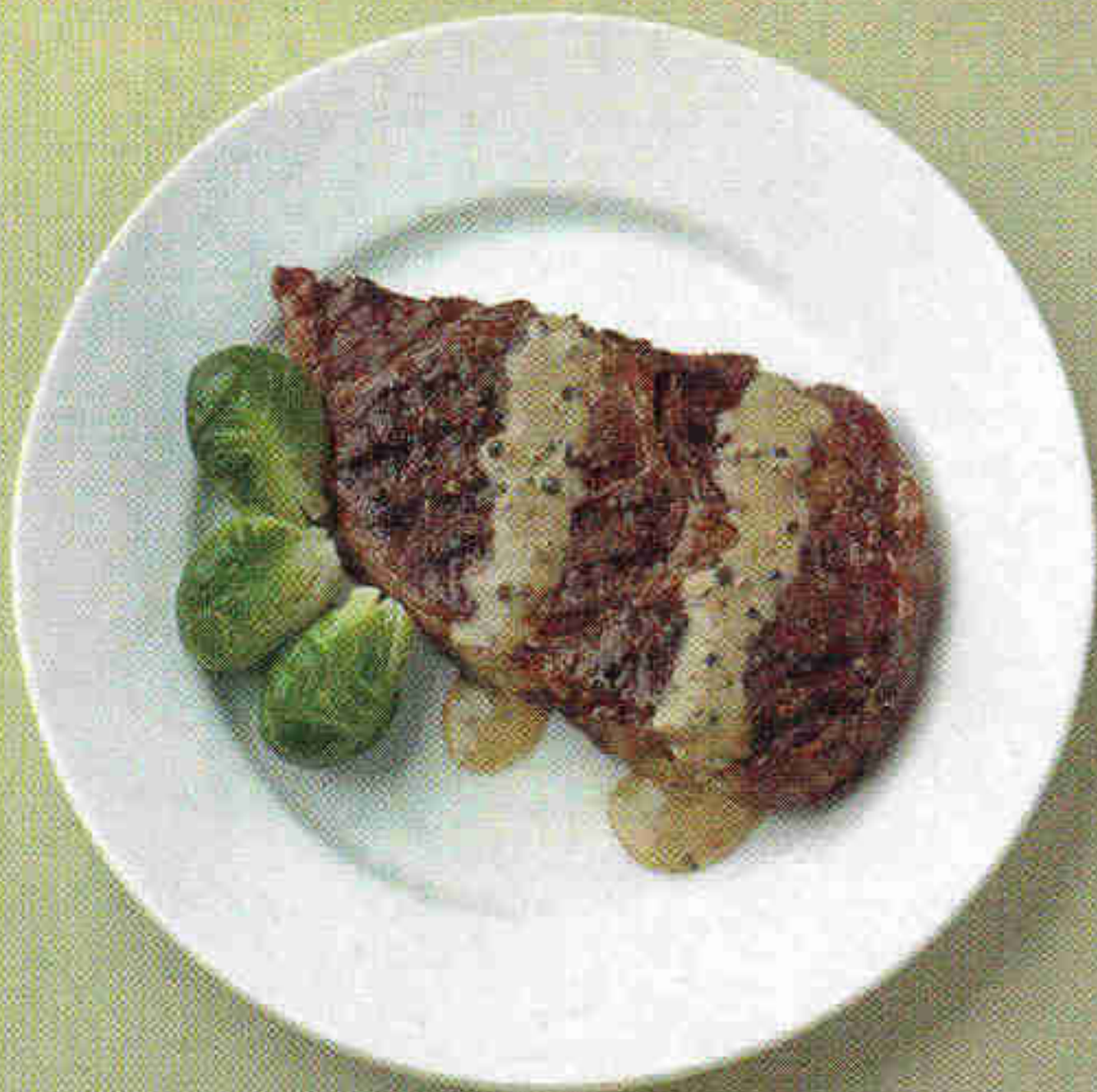
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Cholesterol comes from 2 sources: Food and Family



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You probably know cholesterol comes from food. But what you might not know is that cholesterol has a lot to do with family history. VYTORIN treats both sources of cholesterol.

Only VYTORIN helps block the absorption of cholesterol that comes from food and reduces the cholesterol that your body makes naturally. A healthy diet is important, but when it's not enough, adding VYTORIN can help.

In clinical trials, VYTORIN lowered bad cholesterol more than Lipitor® alone. VYTORIN contains two cholesterol medicines: Zetia® (ezetimibe) and Zocor® (simvastatin) in a single tablet.

Continue to follow a healthy diet, and ask your doctor about adding VYTORIN.

Important information: VYTORIN is a prescription tablet and isn't right for everyone, including women who are nursing or pregnant or who may become pregnant, and anyone with liver problems.

Unexplained muscle pain or weakness could be a sign of a rare but serious side effect and should be reported to your doctor right away. VYTORIN may interact with other medicines or certain foods, increasing your risk of getting this serious side effect. So, tell your doctor about any other medications you are taking.

Please read the Patient Product Information on the adjacent page.

To learn more, simply call 1-877-VYTORIN or visit vytorin.com.



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VYTORIN® (ezetimibe/simvastatin) Tablets

Patient Information about VYTORIN (VI-tor-in)

Generic name: ezetimibe/simvastatin tablets

Read this information carefully before you start taking VYTORIN. Review this information each time you refill your prescription for VYTORIN as there may be new information. This information does not take the place of talking with your doctor about your medical condition or your treatment. If you have any questions about VYTORIN, ask your doctor. Only your doctor can determine if VYTORIN is right for you.

What is VYTORIN?

VYTORIN is a medicine used to lower levels of total cholesterol, LDL (bad) cholesterol, and fatty substances called triglycerides in the blood. In addition, VYTORIN raises levels of HDL (good) cholesterol. It is used for patients who cannot control their cholesterol levels by diet alone. You should stay on a cholesterol-lowering diet while taking this medicine.

VYTORIN works to reduce your cholesterol in two ways. It reduces the cholesterol absorbed in your digestive tract, as well as the cholesterol your body makes by itself. VYTORIN does not help you lose weight.

Who should not take VYTORIN?

Do not take VYTORIN:

- If you are allergic to ezetimibe or simvastatin, the active ingredients in VYTORIN, or to the inactive ingredients. For a list of inactive ingredients, see the "Inactive ingredients" section at the end of this information sheet.
- If you have active liver disease or repeated blood tests indicating possible liver problems.
- If you are pregnant, or think you may be pregnant, or planning to become pregnant or breast-feeding.

VYTORIN is not recommended for use in children under 10 years of age.

What should I tell my doctor before and while taking VYTORIN?

Tell your doctor right away if you experience unexplained muscle pain, tenderness, or weakness. This is because on rare occasions, muscle problems can be serious, including muscle breakdown resulting in kidney damage.

The risk of muscle breakdown is greater at higher doses of VYTORIN.

The risk of muscle breakdown is greater in patients with kidney problems.

Taking VYTORIN with certain substances can increase the risk of muscle problems. It is particularly important to tell your doctor if you are taking any of the following:

- cyclosporine

- danazol
- antifungal agents (such as itraconazole or ketoconazole)
- fibric acid derivatives (such as gemfibrozil, bezafibrate, or fenofibrate)
- the antibiotics erythromycin, clarithromycin, and telithromycin
- HIV protease inhibitors (such as indinavir, nelfinavir, ritonavir, and saquinavir)
- the antidepressant nefazodone
- amiodarone (a drug used to treat an irregular heartbeat)
- verapamil (a drug used to treat high blood pressure, chest pain associated with heart disease, or other heart conditions)
- large doses (≥ 1 g/day) of niacin or nicotinic acid
- large quantities of grapefruit juice (>1 quart daily)

It is also important to tell your doctor if you are taking coumarin anticoagulants (drugs that prevent blood clots, such as warfarin).

Tell your doctor about any prescription and nonprescription medicines you are taking or plan to take, including natural or herbal remedies.

Tell your doctor about all your medical conditions including allergies.

Tell your doctor if you:

- drink substantial quantities of alcohol or ever had liver problems. VYTORIN may not be right for you.
- are pregnant or plan to become pregnant. Do not use VYTORIN if you are pregnant, trying to become pregnant or suspect that you are pregnant. If you become pregnant while taking VYTORIN, stop taking it and contact your doctor immediately.
- are breast-feeding. Do not use VYTORIN if you are breast-feeding.

Tell other doctors prescribing a new medication that you are taking VYTORIN.

How should I take VYTORIN?

- Take VYTORIN once a day, in the evening, with or without food.
- Try to take VYTORIN as prescribed. If you miss a dose, do not take an extra dose. Just resume your usual schedule.
- Continue to follow a cholesterol-lowering diet while taking VYTORIN. Ask your doctor if you need diet information.
- Keep taking VYTORIN unless your doctor tells you to stop. If you stop taking VYTORIN, your cholesterol may rise again.

What should I do in case of an overdose?

Contact your doctor immediately.

What are the possible side effects of VYTORIN?

See your doctor regularly to check your cholesterol level and to check for side effects. Your doctor may do blood tests to check your liver before you start taking VYTORIN and during treatment.

In clinical studies patients reported the following common side effects while taking VYTORIN: headache and muscle pain (see What should I tell my doctor before and while taking VYTORIN?).

The following side effects have been reported in general use with either ezetimibe or simvastatin tablets (tablets that contain the active ingredients of VYTORIN):

- allergic reactions including swelling of the face, lips, tongue, and/or throat that may cause difficulty in breathing or swallowing (which may require treatment right away), rash, hives; joint pain; alterations in some laboratory blood tests; liver problems; inflammation of the pancreas; nausea; gallstones; inflammation of the gallbladder.

Tell your doctor if you are having these or any other medical problems while on VYTORIN. This is not a complete list of side effects. For a complete list, ask your doctor or pharmacist.

General Information about VYTORIN

Medicines are sometimes prescribed for conditions that are not mentioned in patient information leaflets. Do not use VYTORIN for a condition for which it was not prescribed. Do not give VYTORIN to other people, even if they have the same condition you have. It may harm them.

This summarizes the most important information about VYTORIN. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about VYTORIN that is written for health professionals. For additional information, visit the following web site: vytorin.com.

Inactive ingredients:

Butylated hydroxyanisole NF, citric acid monohydrate USP, croscarmellose sodium NF, hydroxypropyl methylcellulose USP, lactose monohydrate NF, magnesium stearate NF, microcrystalline cellulose NF, and propyl gallate NF.

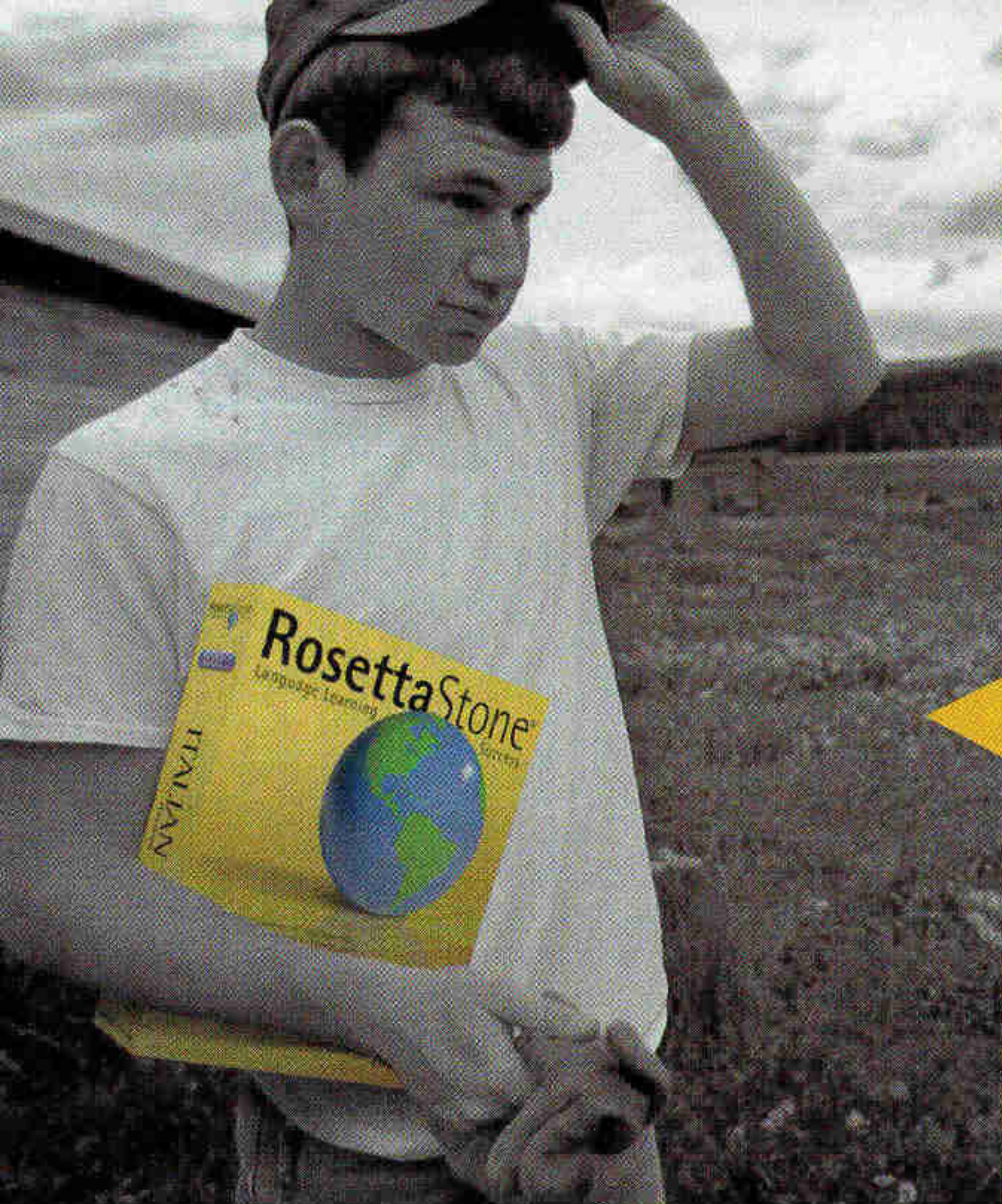
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He was a hardworking farm boy.

She was an Italian supermodel.


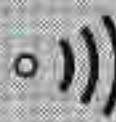


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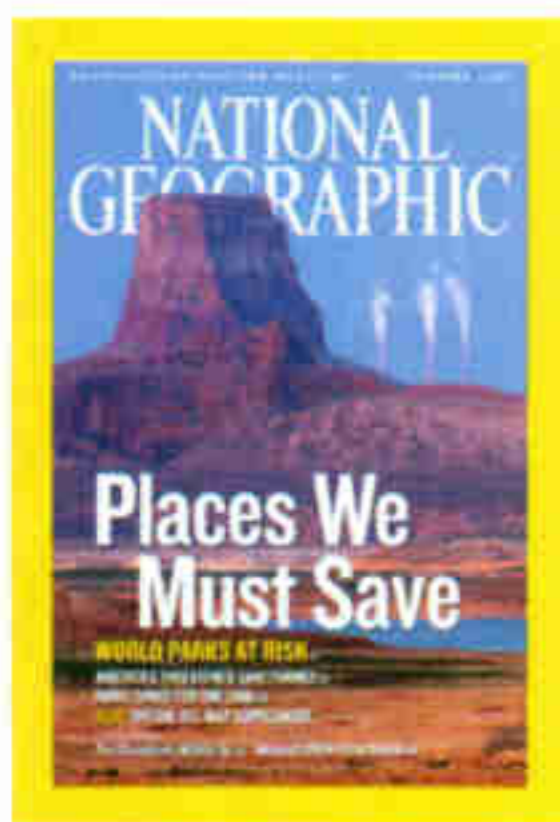
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LETTERS



October 2006 *Parks are clearly close to people's hearts: Readers of all ages wrote in about their own park experiences. But this month's stories divided readers. Some thought the essays were too negative or one-sided. Others were grateful that GEOGRAPHIC shed light on the issues that the National Park Service faces.*

➤ Comment on February stories at ngm.com.

Hallowed Ground

Conflict between conservation and use in our national parks arises when visitors adopt a consumer's attitude toward outdoor recreation. True lovers and stewards of our public lands seek not mechanized entertainment in beautiful locations, but the intrinsic value of unspoiled spaces.

JOSEPH M. LANGENHAN
Seattle, Washington

We applaud NATIONAL GEOGRAPHIC's attention to the state of the U.S. National Park System. Chronic funding shortfalls in excess of 800 million dollars annually have put our national heritage at risk. The new Secretary of the Interior, Dirk Kempthorne, has expressed interest in addressing these funding needs, and the Bush Administration's announced launch of the National Park

Centennial Challenge has the potential to do just that. We hope that the issues raised in your magazine will encourage Americans to contact the administration and Congress and urge them to meet this commitment and restore the faded glory of America's national parks by their 100th birthday—just nine years away.

TOM KIERNAN
President, National Parks
Conservation Association
Washington, D.C.

I was appalled when I saw the cover photo of Glen Canyon National Recreation Area. It is shameful that Americans could build a power plant that stands in full view of the natural landscape in that area. What were they thinking? I realize that in

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Iguazu Falls on the Argentina-Brazil border.

present times nothing is sacred,
but come on, America!

CAROL STEWART
Cape Coral, Florida

The chimneys on the cover symbolize to me that we live in a gorgeous land of great opportunity where people of all origins, within sight of great beauty, are free to use their ingenuity and personal resources to produce electricity and other products that make possible the high standard of living that we enjoy at work and leisure. Moral: If you don't like the chimneys, shoot the butte from a different angle.

JACK S. HICKS
Fort Worth, Texas

John Mitchell's "Threatened Sanctuaries" is more fiction

than essay. How do I know? I am married to one of the persons vilified by this article. Paul Hoffman, a former wilderness guide, co-founder of a grassroots environmental group, and a leave-no-trace proponent, is a public servant who came to Washington, D.C., to preserve the conservation and enjoyment of our parks for present and future generations. Hoffman was never contacted to respond to this hatchet job. One of Mitchell's sources is a special interest group, which was formed specifically to undermine President Bush's reelection efforts. Shame on NATIONAL GEOGRAPHIC for giving platform to irresponsible and lazy tabloid journalism.

LISA HOFFMAN
Sterling, Virginia

John Mitchell and the editors stand by the accuracy of his essay, as well as the integrity and fairness of the reporting.

You will probably get criticism for the national parks article by people who feel you have made a partisan attack on the Bush Administration and some Republicans in Congress. I am

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LETTERS

congratulating you for stating the obvious. Our parks are suffering badly because of wrongheaded financial priorities and ideas about best use.

GAY KRAMER-DODD
Eugene, Oregon

This is a wonderful article highlighting the precious gift we Americans have in our national parks. There is a funding crisis that I contribute to by being a senior. At age 62, one can receive a Golden Age Passport that costs only ten dollars for life! I have used mine frequently. With approximately 2.9 million Americans turning 60 this year, I feel strongly that seniors can contribute more to the parks that we cherish.

JOACHIM F. WIRTH
Coeur d'Alene, Idaho

"Now we must learn how to speak with the people who haven't been coming," Howard Levitt of Golden Gate National Recreation Area said in your article. The people who haven't been coming to national parks,

or who come but look bored, are young kids. Several years ago I discovered the Junior Ranger program, in which you complete a booklet as you go around the park and get a badge as a souvenir. I enjoyed it so much that I set up a website to display my badges and inform other kids about the program (*juniorranger.info*). It allows kids to learn things about nature, history, and culture in a fun way. I've got over 250 badges and patches, and even though I'm 13 now, I hope to visit more parks.

SAM MASLOW
Brooklyn, New York

I feel that today's environmental challenge is coordinating urbanization with nature. Thank you for reminding your readers that we thrive in nature. Hopefully city planners will begin to integrate nature and cities as a catalyst for the health of residents.

MARISSA MARKOWITZ
Fairfield, Iowa

The article on Paris parks was interesting reading. But I think the statistic that 30 percent of Paris is park space is misleading, since most of that space is concentrated in only two parks—Bois de Boulogne and Bois de Vincennes, which are mostly urban forests and quite unsafe at night. Perhaps a better measure of urban parks is how evenly they are dispersed throughout the city. For example, in Paris many of the suburbs that are crowded with housing projects and disaffected immigrants have hardly any parks, which can only increase the residents' alienation.

ANDY PATTERSON
Washington, D.C.

Corrections, Clarifications

October 2006:

Map Supplement: U.S. We regret that the following place-names were misspelled on the map: Southold, NY; Barberton, OH; Elizabethton, TN; Suwannee, FL; Tavares, FL; Isle Royale, MI; Keweenaw Bay, MI; St. Joseph, LA; Thibodaux, LA; Terrebonne Bay, LA; Ridgway, CO; Centerfield, UT; Marysville, UT; Ni'ihau, HI.

Pollution Within Phthalates are no longer used in the manufacture of food wrap as mentioned on pages 123, 128, and 135. Nor are they used in water bottles (page 135). Phthalates are plasticizers with a variety of uses, such as dissolving fragrances and making PVC flexible.



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On February 3rd, 2006, Rune Gjeldnes arrived in Victoria Land, finishing his conquest of skiing solo across Antarctica, from Queen Maud Land via the South Pole. After traversing 4,804 kilometers of the Earth's most inhospitable landscapes, he became the world's first explorer to cross Greenland lengthways, the North Pole ice cap and Antarctica on skis unaided. Congratulations, Rune. The world is yours, from top to bottom.



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LETTERS

Is there no hope? Between endangered land, chemical poisons in our bodies, deformed children, and grisly human sacrifice, it was hard to decide which was the most distressing article in your issue. Thankfully you included a wonderful article on the way Paris has incorporated green spaces into its busy urban life. It's not that I don't commend you for your brave and honest approach to these horrific problems. I just feel we need to augment them with some positive stories of action being taken to correct these disastrous situations.

DAVID MICHAEL MASSEE
Waterford Works, New Jersey

Pollution Within

Thanks a million for the fantastic article. I suffer from multiple

chemical sensitivity, a serious and devastating condition that is ignored or misunderstood by mainstream medicine in the U.S. I have no doubt that as more people exceed the limit of chemical exposures the body can detoxify, this illness and other chronic conditions will increase in incidence. Doctors must look beyond the germ theory of disease and realize that synthetic chemicals sicken and kill too.

PAULA MATHESON
Spokane, Washington

After you strike the fear of God into the heart of this mother of two, you leave me wondering what alternatives you can suggest to plastic baby bottles and toys, as well as the other apparently harmful yet unavoidable

dangers lurking in my home. I would appreciate a subsequent article that informs your readers about ways to minimize their exposure to potentially toxic substances.

VICTORIA KONAR
Houston, Texas

Many readers asked how to avoid harmful chemicals. We included basic information in the chart on pages 134-5. For more details about sources of exposure, go to the U.S. Environmental Protection Agency's website at epa.gov. Advocacy organizations such as the Environmental Working Group also profile chemicals and the products containing them. Some compounds, however, pervade the environment and can't be avoided.



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Ed Huerta: There are places that really do have a way of calling to you. Not with words, but with the beauty of the landscape.



Mount Dana, Inyo National Forest

Ed Huerta: And I just have to answer it. I have to be here. I need to be here. I really don't have a choice - it's where my heart is.

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Reader's Choice For this issue's Your Shot we asked readers simply to "send us something wonderful." The pictures we received were so good, our editors have decided to continue the photographic free-for-all. Submit one of your own favorite photos—on any topic—for possible publication in an upcoming issue of NATIONAL GEOGRAPHIC. For guidelines, a submission form, and more information, go to ngm.com/yourshot.

Terry Stevens
Scottsdale, Arizona

Before helping this bobcat down from a 30-foot saguaro with a bag net on a pole, Terry Stevens snapped the stranded animal—which then bounded off, unhurt, into the surrounding desert. "There had been mountain lion sightings in the area," says Stevens, 58—an airline pilot when not plucking cats off cactuses. "That might be what chased him up there."

Tim Gainey
Banbury, England

Several weeks and many mealworms were spent waiting for this wild European robin to pose on a white backdrop placed in his garden, explains photographer Tim Gainey, 39. "This shot sums up the character of that little bird," he says.



They said give up.
They said it couldn't be done.
They said I'd regret it.
They were wrong.

My dream is to rise to every challenge.

And from up here,
all the mountains look like molehills.



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Brigittine monks in a Woodside, California, monastery gather for prayers.

Ed Kashi is a freelance photojournalist who has produced 12 feature stories for NATIONAL GEOGRAPHIC.

Observing the Faithful In the hills of northern California, I once came upon a mansion straight out of Tuscany. It was a monastery filled with a darkness and quiet I'd always associated with the Middle Ages—not the soon-to-arrive 21st century being crafted by the companies of Silicon Valley just miles away. I was there from the *Los Angeles Times* to photograph Brigittine monks who ran a candymaking business at the monastery. As I left, they gave me fudge to take home. Unfortunately, I hate fudge.

But I love the timeless quality of this photograph. I was only 24 at the time and I had no idea what further explorations of faith would await me as my career unfolded over the next 25 years.

I'll never forget photographing Friday prayers at a Baghdad mosque in April 2004. Some 10,000 angry worshippers, both Sunni and Shiite, had come. They shouted, "Death to America! Death to Israel!" The level of hatred and anger was overwhelming.

A far more peaceful situation I covered was an Orthodox Easter Mass attended by thousands of Christians at Jerusalem's Church of the Holy Sepulchre. The situation was similar to the one in Baghdad in that there were far too many people pushing into the crowded hall, and emotions ran high. But the mood was one of passionate belief and peaceful cooperation. That's not always easy to find when covering people at prayer in today's world.

👉 **Web Exclusive** Explore Ed Kashi's work at ngm.com/0601/feature1.



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Important Safety Information

AMBIEN is indicated for the short-term treatment of insomnia.

When you first start taking AMBIEN, use caution in the morning when engaging in activities requiring complete alertness until you know how you will react to this medication. In most instances, memory problems can be avoided if you take AMBIEN only when you are able to get a full night's sleep (7 to 8 hours) before you need to be active again. As with any sleep medication, do not use alcohol while you are taking AMBIEN.

Prescription sleep aids are often taken for 7 to 10 days — or longer as advised by your doctor. Like most sleep medicines, it has some risk of dependency.

There is a low occurrence of side effects associated with the short-term use of AMBIEN. The most commonly observed side effects in controlled clinical trials were drowsiness (2%), dizziness (1%), and diarrhea (1%).

AMBIEN CR is indicated for treating insomnia.

It is a treatment option you and your doctor can consider along with lifestyle changes and can be taken for as long as your doctor recommends. Until you know how AMBIEN CR will affect you, you shouldn't drive or operate machinery. Be sure you're able to devote 7 to 8 hours to sleep before being active again. Side effects may include next-day drowsiness, dizziness and headache. It's non-narcotic; however, like most sleep medicines, it has some risk of dependency. Don't take it with alcohol.


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Ambien®

(zolpidem tartrate)

INDICATIONS AND USAGE

Ambien (zolpidem tartrate) is indicated for the short-term treatment of insomnia. Ambien has been shown to decrease sleep latency and increase the duration of sleep for up to 35 days in controlled clinical studies (see *Clinical Pharmacology: Controlled trials supporting safety and efficacy*). The clinical trials performed in support of efficacy were 4-5 weeks in duration with the final formal assessments of sleep latency performed at the end of treatment.

CONTRAINDICATIONS

Ambien is contraindicated in patients with known hypersensitivity to zolpidem tartrate or to any of the inactive ingredients in the formulation.

WARNINGS

Because sleep disturbances may be the presenting manifestation of a physical and/or psychiatric disorder, symptomatic treatment of insomnia should be initiated only after a careful evaluation of the patient. **The failure of insomnia to remit after 7 to 10 days of treatment may indicate the presence of a primary psychiatric and/or medical illness that should be evaluated.** Worsening of insomnia or the emergence of new thinking or behavior abnormalities may be the consequence of an unrecognized psychiatric or physical disorder. Such findings have emerged during the course of treatment with sedative/hypnotic drugs, including Ambien. Because some of the important adverse effects of Ambien appear to be dose related (see *Precautions and Dosage and Administration*), it is important to use the smallest possible effective dose, especially in the elderly.

A variety of abnormal thinking and behavior changes have been reported to occur in association with the use of sedative/hypnotics. Some of these changes may be characterized by decreased inhibition (eg, aggressiveness and extroversion that seemed out of character), similar to effects produced by alcohol and other CNS depressants. Other reported behavioral changes have included bizarre behavior, agitation, hallucinations, and depersonalization. Amnesia and other neuropsychiatric symptoms may occur unpredictably. In primarily depressed patients, worsening of depression, including suicidal thinking, has been reported in association with the use of sedative/hypnotics.

It can rarely be determined with certainty whether a particular instance of the abnormal behaviors listed above is drug induced, spontaneous in origin, or a result of an underlying psychiatric or physical disorder. Nonetheless, the emergence of any new behavioral sign or symptom of concern requires careful and immediate evaluation.

Following the rapid dose decrease or abrupt discontinuation of sedative/hypnotics, there have been reports of signs and symptoms similar to those associated with withdrawal from other CNS-depressant drugs (see *Drug Abuse and Dependence*).

Ambien, like other sedative/hypnotic drugs, has CNS-depressant effects. Due to the rapid onset of action, Ambien should only be ingested immediately prior to going to bed. Patients should be cautioned against engaging in hazardous occupations requiring complete mental alertness or motor coordination such as operating machinery or driving a motor vehicle after ingesting the drug, including potential impairment of the performance of such activities that may occur the day following ingestion of Ambien. Ambien showed additive effects when combined with alcohol and should not be taken with alcohol. Patients should also be cautioned about possible combined effects with other CNS-depressant drugs. Dosage adjustments may be necessary when Ambien is administered with such agents because of the potentially additive effects.

PRECAUTIONS

General

Use in the elderly and/or debilitated patients: Impaired motor and/or cognitive performance after repeated exposure or unusual sensitivity to sedative/hypnotic drugs is a concern in the treatment of elderly and/or debilitated patients. Therefore, the recommended Ambien dosage is 5 mg in such patients (see *Dosage and Administration*) to decrease the possibility of side effects. These patients should be closely monitored.

Use in patients with concomitant illness: Clinical experience with Ambien (zolpidem tartrate) in patients with concomitant systemic illness is limited. Caution is advisable in using Ambien in patients with diseases or conditions that could affect metabolism or hemodynamic responses. Although studies did not reveal respiratory depressant effects at hypnotic doses of Ambien in normals or in patients with mild to moderate chronic obstructive pulmonary disease (COPD), a reduction in the Total Arousal Index together with a reduction in lowest oxygen saturation and increase in the times of oxygen desaturation below 80% and 90% was observed in patients with mild-to-moderate sleep apnea when treated with Ambien (10 mg) when compared to placebo. However, precautions should be observed if Ambien is prescribed to patients with compromised respiratory function, since sedative/hypnotics have the capacity to depress respiratory drive. Post-marketing reports of respiratory insufficiency, most of which involved patients with pre-existing respiratory impairment, have been received. Data in end-stage renal failure patients repeatedly treated with Ambien did not demonstrate drug accumulation or alterations in pharmacokinetic parameters. No dosage adjustment in renally impaired patients is required; however, these patients should be closely monitored (see *Pharmacokinetics*). A study in subjects with hepatic impairment did reveal prolonged elimination in this group; therefore, treatment should be initiated with 5 mg in patients with hepatic compromise, and they should be closely monitored.

Use in depression: As with other sedative/hypnotic drugs, Ambien should be administered with caution to patients exhibiting signs or symptoms of depression. Suicidal tendencies may be present in such patients and protective measures may be required. Intentional overdose is more common in this group of patients; therefore, the least amount of drug that is feasible should be prescribed for the patient at any one time.

Information for patients: Patient information is printed at the end of this insert. To assure safe and effective use of Ambien, this information and instructions provided in the patient information section should be discussed with patients.

Laboratory tests: There are no specific laboratory tests recommended.

Drug interactions

CNS-active drugs: Ambien was evaluated in healthy volunteers in single-dose interaction studies for several CNS drugs. A study involving haloperidol and zolpidem revealed no effect of haloperidol on the pharmacokinetics or pharmacodynamics of zolpidem. Imipramine in combination with zolpidem produced no pharmacokinetic interaction other than a 20% decrease in peak levels of imipramine, but there was an additive effect of decreased alertness. Similarly, chlorpromazine in combination with zolpidem produced no pharmacokinetic interaction, but there was an additive effect of decreased alertness and psychomotor performance. The lack of a drug interaction following single-dose administration does not predict a lack following chronic administration.

An additive effect on psychomotor performance between alcohol and zolpidem was demonstrated. A single-dose interaction study with zolpidem 10 mg and fluoxetine 20 mg at steady-state levels in male volunteers did not demonstrate any clinically significant pharmacokinetic or pharmacodynamic interactions. When multiple doses of zolpidem and fluoxetine at steady-state concentrations were evaluated in healthy females, the only significant change was a 17% increase in the zolpidem half-life. There was no evidence of an additive effect in psychomotor performance.

Following five consecutive nightly doses of zolpidem 10 mg in the presence of sertraline 50 mg (17 consecutive daily doses, at 7:00 am, in healthy female volunteers), zolpidem C_{max} was significantly higher (43%) and T_{max} was significantly decreased (53%). Pharmacokinetics of sertraline and N-desmethylsertraline were unaffected by zolpidem.

Since the systematic evaluations of Ambien (zolpidem tartrate) in combination with other CNS-active drugs have been limited, careful consideration should be given to the pharmacology of any CNS-active drug to be used with zolpidem. Any drug with CNS-depressant effects could potentially enhance the CNS-depressant effects of zolpidem.

Drugs that affect drug metabolism via cytochrome P450: A randomized, double-blind, crossover interaction study in ten healthy volunteers between itraconazole (200 mg once daily for 4 days) and

a single dose of zolpidem (10 mg) given 5 hours after the last dose of itraconazole resulted in a 34% increase in AUC_{0-24} of zolpidem. There were no significant pharmacodynamic effects of zolpidem on subjective drowsiness, postural sway, or psychomotor performance.

A randomized, placebo-controlled, crossover interaction study in eight healthy female volunteers between 5 consecutive daily doses of rifampin (600 mg) and a single dose of zolpidem (20 mg) given 17 hours after the last dose of rifampin showed significant reductions of the AUC (-73%), C_{max} (-58%), and $T_{1/2}$ (-36%) of zolpidem together with significant reductions in the pharmacodynamic effects of zolpidem.

Other drugs: A study involving cimetidine/zolpidem and ranitidine/zolpidem combinations revealed no effect of either drug on the pharmacokinetics or pharmacodynamics of zolpidem. Zolpidem had no effect on digoxin kinetics and did not affect prothrombin time when given with warfarin in normal subjects. Zolpidem's sedative/hypnotic effect was reversed by flumazenil; however, no significant alterations in zolpidem pharmacokinetics were found.

Drug/Laboratory test interactions: Zolpidem is not known to interfere with commonly employed clinical laboratory tests. In addition, clinical data indicate that zolpidem does not cross-react with benzodiazepines, opiates, barbiturates, cocaine, cannabinoids, or amphetamines in two standard urine drug screens.

Carcinogenesis, mutagenesis, impairment of fertility

Carcinogenesis: Zolpidem was administered to rats and mice for 2 years at dietary dosages of 4, 18, and 80 mg/kg/day. In mice, these doses are 26 to 520 times or 2 to 35 times the maximum 10-mg human dose on a mg/kg or mg/m² basis, respectively. In rats these doses are 43 to 876 times or 6 to 115 times the maximum 10-mg human dose on a mg/kg or mg/m² basis, respectively. No evidence of carcinogenic potential was observed in mice. Renal liposarcomas were seen in 4/100 rats (3 males, 1 female) receiving 80 mg/kg/day and a renal lipoma was observed in one male rat at the 18 mg/kg/day dose. Incidence rates of lipoma and liposarcoma for zolpidem were comparable to those seen in historical controls and the tumor findings are thought to be a spontaneous occurrence.

Mutagenesis: Zolpidem did not have mutagenic activity in several tests including the Ames test, genotoxicity in mouse lymphoma cells in vitro, chromosomal aberrations in cultured human lymphocytes, unscheduled DNA synthesis in rat hepatocytes in vitro, and the micronucleus test in mice.

Impairment of fertility: In a rat reproduction study, the high dose (100 mg base/kg) of zolpidem resulted in irregular estrus cycles and prolonged preovulatory intervals, but there was no effect on male or female fertility after daily oral doses of 4 to 100 mg base/kg or 5 to 130 times the recommended human dose in mg/m². No effects on any other fertility parameters were noted.

Pregnancy

Teratogenic effects: Pregnancy Category C.

Zolpidem tartrate was administered to pregnant Sprague-Dawley rats by oral gavage during the period of organogenesis at doses of 4, 20, or 100 mg base/kg/day. Adverse maternal and embryo/fetal effects occurred at doses of 20 mg base/kg and higher, manifesting as dose-related lethargy and ataxia in pregnant rats while examination of fetal skull bones revealed a dose-related trend toward incomplete ossification. Teratogenicity was not observed at any dose level. The no-effect dose of zolpidem for maternal and embryofetal toxicity was 4 mg base/kg/day (between 4 to 5 times the MRHD of Ambien on a mg/m² basis).

Administration of zolpidem tartrate to pregnant Himalayan Albino rabbits at doses of 1, 4, or 16 mg base/kg/day by oral gavage (over 35 times the MRHD of Ambien, on a mg/m² basis) during the period of organogenesis produced dose-related maternal sedation and decreased maternal body weight gain at all doses. At the high dose of 16 mg base/kg, there was an increase in post-implantation fetal loss and under-ossification of sternebrae in viable fetuses. Teratogenicity was not observed at any dose level. The no-effect dose of zolpidem for maternal toxicity was below 1 mg base/kg/day (< 2-times the MRHD of Ambien on a mg/m² basis). The no-effect dose for embryo-fetal toxicity was 4 mg base/kg/day (between 9 and 10 times the MRHD of Ambien on a mg/m² basis). Administration of zolpidem tartrate at doses of 4, 20, or 100 mg base/kg/day to pregnant Sprague-Dawley rats starting on Day 15 of gestation and continuing through Day 21 of the postnatal lactation period produced dose-dependent lethargy and ataxia in dams at doses of 20 mg base/kg and higher. Decreased maternal body weight gain as well as evidence on non-secreting mammary glands and a single incidence of maternal death was observed at 100 mg base/kg. Effects observed on rat pups included decreased body weight with maternal doses of 20 mg base/kg and higher and decreased pup survival at maternal doses of 100 mg base/kg. The no-effect dose for maternal and offspring toxicity was 4 mg base/kg (between 4 to 5 times the MRHD of Ambien on a mg/m² basis). There are no adequate and well-controlled studies in pregnant women. Ambien should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Nonteratogenic effects: Studies to assess the effects on children whose mothers took zolpidem during pregnancy have not been conducted. However, children born of mothers taking sedative/hypnotic drugs may be at some risk for withdrawal symptoms from the drug during the postnatal period. In addition, neonatal flaccidity has been reported in infants born of mothers who received sedative/hypnotic drugs during pregnancy.

Labor and delivery: Ambien (zolpidem tartrate) has no established use in labor and delivery.

Nursing mothers:

Studies in lactating mothers indicate that the half-life of zolpidem is similar to that in young normal volunteers (2.6 ± 0.3 hr). Between 0.004 and 0.019% of the total administered dose is excreted into milk, but the effect of zolpidem on the infant is unknown.

In addition, in a rat study, zolpidem inhibited the secretion of milk. The no-effect dose was 4 mg base/kg or 6 times the recommended human dose in mg/m². The use of Ambien in nursing mothers is not recommended.

Pediatric use:

Safety and effectiveness in pediatric patients below the age of 18 have not been established.

Geriatric use:

A total of 154 patients in U.S. controlled clinical trials and 897 patients in non-U.S. clinical trials who received zolpidem were ≥60 years of age. For a pool of U.S. patients receiving zolpidem at doses of ≤10 mg or placebo, there were three adverse events occurring at an incidence of at least 3% for zolpidem and for which the zolpidem incidence was at least twice the placebo incidence (ie, they could be considered drug related).

Adverse Event	Zolpidem	Placebo
Dizziness	3%	0%
Drowsiness	5%	2%
Diarrhea	3%	1%

A total of 30/1,959 (1.5%) non-U.S. patients receiving zolpidem reported falls, including 28/30 (93%) who were ≥70 years of age. Of these 28 patients, 23 (82%) were receiving zolpidem doses >10 mg. A total of 24/1,959 (1.2%) non-U.S. patients receiving zolpidem reported confusion, including 18/24 (75%) who were ≥70 years of age. Of these 18 patients, 14 (78%) were receiving zolpidem doses >10 mg.

ADVERSE REACTIONS

Associated with discontinuation of treatment: Approximately 4% of 1,701 patients who received zolpidem at all doses (1.25 to 90 mg) in U.S. premarketing clinical trials discontinued treatment because of an adverse clinical event. Events most commonly associated with discontinuation from U.S. trials were daytime drowsiness (0.5%), dizziness (0.4%), headache (0.5%), nausea (0.6%), and vomiting (0.5%).

Approximately 4% of 1,959 patients who received zolpidem at all doses (1 to 50 mg) in similar foreign trials discontinued treatment because of an adverse event. Events most commonly associated with discontinuation from these trials were daytime drowsiness (1.1%), dizziness/vertigo (0.8%), amnesia (0.5%), nausea (0.5%), headache (0.4%), and falls (0.4%).

Data from a clinical study in which selective serotonin reuptake inhibitor (SSRI) treated patients were given zolpidem revealed that four of the seven discontinuations during double-blind treatment with zolpidem (n=95) were associated with impaired concentration, continuing or aggravated depression, and manic reaction; one patient treated with placebo (n=97) was discontinued after an attempted suicide.

Incidence in controlled clinical trials

Most commonly observed adverse events in controlled trials: During short-term treatment (up to 10 nights) with Ambien at doses up to 10 mg, the most commonly observed adverse events associated with the use of zolpidem and seen at statistically significant differences from placebo-treated patients were drowsiness (reported by 2% of zolpidem patients), dizziness (1%), and diarrhea (1%). During longer-term treatment (28 to 35 nights) with zolpidem at doses up to 10 mg, the most commonly observed adverse events associated with the use of zolpidem and seen at statistically significant differences from placebo-treated patients were dizziness (5%) and drugged feelings (3%).

Adverse events observed at an incidence of ≥1% in controlled trials: The following tables enumerate treatment-emergent adverse event frequencies that were observed at an incidence equal to 1% or greater among patients with insomnia who received Ambien in U.S. placebo-controlled trials. Events reported by investigators were classified utilizing a modified World Health Organization (WHO) dictionary of preferred terms for the purpose of establishing event frequencies. The prescriber should be aware that these figures cannot be used to predict the incidence of side effects in the course of usual medical practice, in which patient characteristics and other factors differ from those that prevailed in these clinical trials. Similarly, the cited frequencies cannot be compared with figures obtained from other clinical investigators involving related drug products and uses, since each group of drug trials is conducted under a different set of conditions. However, the cited figures provide the physician with a basis for estimating the relative contribution of drug and nondrug factors to the incidence of side effects in the population studied.

The following table was derived from a pool of 11 placebo-controlled short-term U.S. efficacy trials involving zolpidem in doses ranging from 1.25 to 20 mg. The table is limited to data from doses up to and including 10 mg, the highest dose recommended for use.

Incidence of Treatment-Emergent Adverse Experiences in Short-term Placebo-Controlled Clinical Trials
(Percentage of patients reporting)

Body System/ Adverse Event*	Zolpidem (≤10 mg) (N=685)	Placebo (N=473)
Central and Peripheral Nervous System		
Headache	7	6
Drowsiness	2	—
Dizziness	1	—
Gastrointestinal System		
Nausea	2	3
Diarrhea	1	—
Musculoskeletal System		
Myalgia	1	2

*Events reported by at least 1% of Ambien patients are included

The following table was derived from a pool of three placebo-controlled long-term efficacy trials involving Ambien (zolpidem tartrate). These trials involved patients with chronic insomnia who were treated for 28 to 35 nights with zolpidem at doses of 5, 10, or 15 mg. The table is limited to data from doses up to and including 10 mg, the highest dose recommended for use. The table includes only adverse events occurring at an incidence of at least 1% for zolpidem patients.

Incidence of Treatment-Emergent Adverse Experiences in Long-term Placebo-Controlled Clinical Trials
(Percentage of patients reporting)

Body System/ Adverse Event*	Zolpidem (≤10 mg) (N=152)	Placebo (N=161)
Autonomic Nervous System		
Dry mouth	3	1
Body as a Whole		
Allergy	4	1
Back pain	3	2
Influenza-like symptoms	2	—
Chest pain	1	—
Fatigue	1	2
Cardiovascular System		
Palpitation	2	—
Central and Peripheral Nervous System		
Headache	19	22
Drowsiness	8	5
Dizziness	5	1
Lethargy	3	1
Drugged feeling	3	—
Lightheadedness	2	1
Depression	2	1
Abnormal dreams	1	—
Amnesia	1	—
Anxiety	1	1
Nervousness	1	3
Sleep disorder	1	—
Gastrointestinal System		
Nausea	6	6
Dyspepsia	5	6
Diarrhea	3	2
Abdominal pain	2	2
Constipation	2	1
Anorexia	1	1
Vomiting	1	1
Immunologic System		
Infection	1	1
Musculoskeletal System		
Myalgia	7	7
Arthralgia	4	4
Respiratory System		
Upper respiratory infection	5	6
Sinusitis	4	2
Pharyngitis	3	1
Rhinitis	1	3
Skin and Appendages		
Rash	2	1
Urogenital System		
Urinary tract infection	2	2

*Events reported by at least 1% of patients treated with Ambien.

Dose relationship for adverse events: There is evidence from dose comparison trials suggesting a dose relationship for many of the adverse events associated with zolpidem use, particularly for certain CNS and gastrointestinal adverse events.

Adverse event incidence across the entire preapproval database: Ambien (zolpidem tartrate) was administered to 3,660 subjects in clinical trials throughout the U.S., Canada, and Europe. Treatment-

emergent adverse events associated with clinical trial participation were recorded by clinical investigators using terminology of their own choosing. To provide a meaningful estimate of the proportion of individuals experiencing treatment-emergent adverse events, similar types of untoward events were grouped into a smaller number of standardized event categories and classified utilizing a modified World Health Organization (WHO) dictionary of preferred terms. The frequencies presented, therefore, represent the proportions of the 3,660 individuals exposed to zolpidem, at all doses, who experienced an event of the type cited on at least one occasion while receiving zolpidem. All reported treatment-emergent adverse events are included, except those already listed in the table above of adverse events in placebo-controlled studies, those coding terms that are so general as to be uninformative, and those events where a drug cause was remote. It is important to emphasize that, although the events reported did occur during treatment with Ambien, they were not necessarily caused by it.

Adverse events are further classified within body system categories and enumerated in order of decreasing frequency using the following definitions: frequent adverse events are defined as those occurring in greater than 1/100 subjects; infrequent adverse events are those occurring in 1/100 to 1/1,000 patients; rare events are those occurring in less than 1/1,000 patients.

Autonomic nervous system: Infrequent: increased sweating, pallor, postural hypotension, syncope. Rare: abnormal accommodation, altered saliva, flushing, glaucoma, hypotension, impotence, increased saliva, tenesmus.

Body as a whole: Frequent: asthenia. Infrequent: edema, falling, fever, malaise, trauma. Rare: allergic reaction, allergy aggravated, anaphylactic shock, face edema, hot flashes, increased ESR, pain, restless legs, rigors, tolerance increased, weight decrease.

Cardiovascular system: Infrequent: cerebrovascular disorder, hypertension, tachycardia. Rare: angina pectoris, arrhythmia, arteritis, circulatory failure, extrasystoles, hypertension aggravated, myocardial infarction, phlebitis, pulmonary embolism, pulmonary edema, varicose veins, ventricular tachycardia.

Central and peripheral nervous system: Frequent: ataxia, confusion, euphoria, insomnia, vertigo. Infrequent: agitation, decreased cognition, detached, difficulty concentrating, dysarthria, emotional lability, hallucination, hypoesthesia, illusion, leg cramps, migraine, paresthesia, sleeping (after daytime dosing), speech disorder, stupor, tremor. Rare: abnormal gait, abnormal thinking, aggressive reaction, apathy, appetite increased, decreased libido, delusion, dementia, depersonalization, dysphasia, feeling strange, hypokinesia, hypotonia, hysteria, intoxicated feeling, manic reaction, neuralgia, neuritis, neuropathy, neurosis, panic attacks, paresis, personality disorder, somnambulism, suicide attempts, tetany, yawning.

Gastrointestinal system: Frequent: hiccup. Infrequent: constipation, dysphagia, flatulence, gastroenteritis. Rare: enteritis, eructation, esophagospasm, gastritis, hemorrhoids, intestinal obstruction, rectal hemorrhage, tooth caries.

Hematologic and lymphatic system: Rare: anemia, hyperhemoglobinemia, leukopenia, lymphadenopathy, macrocytic anemia, purpura, thrombosis.

Immunologic system: Rare: abscess herpes simplex herpes zoster, otitis externa, otitis media.

Liver and biliary system: Infrequent: abnormal hepatic function, increased SGPT. Rare: bilirubinemia, increased SGOT.

Metabolic and nutritional: Infrequent: hyperglycemia, thirst. Rare: gout, hypercholesterolemia, hyperlipidemia, increased alkaline phosphatase, increased BUN, periorbital edema.

Musculoskeletal system: Infrequent: arthritis. Rare: arthrosis, muscle weakness, sciatica, tendinitis.

Reproductive system: Infrequent: menstrual disorder, vaginitis. Rare: breast fibroadenosis, breast neoplasm, breast pain.

Respiratory system: Infrequent: bronchitis, coughing, dyspnea. Rare: bronchospasm, epistaxis, hypoxia, laryngitis, pneumonia.

Skin and appendages: Infrequent: pruritus. Rare: acne, bullous eruption, dermatitis, furunculosis, injection-site inflammation, photosensitivity reaction, urticaria.

Special senses: Frequent: diplopia, vision abnormal. Infrequent: eye irritation, eye pain, scleritis, taste perversion, tinnitus. Rare: conjunctivitis, corneal ulceration, lacrimation abnormal, parosmia, photopsia.

Urogenital system: Infrequent: cystitis, urinary incontinence. Rare: acute renal failure, dysuria, micturition frequency, nocturia, polyuria, pyelonephritis, renal pain, urinary retention.

DRUG ABUSE AND DEPENDENCE

Controlled substance: Zolpidem tartrate is classified as a Schedule IV controlled substance by federal regulation.

Abuse and dependence: Abuse and addiction are separate and distinct from physical dependence and tolerance. Abuse is characterized by misuse of the drug for non-medical purposes, often in combination with other psychoactive substances. Physical dependence is a state of adaptation that is manifested by a specific withdrawal syndrome that can be produced by abrupt cessation, rapid dose reduction, decreasing blood level of the drug, and/or administration of an antagonist. Tolerance is a state of adaptation in which exposure to a drug induces changes that result in a diminution of one or more of the drug effects over time. Tolerance may occur to both desired and undesired effects of drugs and may develop at different rates for different effects.

Addiction is a primary, chronic, neurobiological disease with genetic, psychosocial, and environmental factors influencing its development and manifestations. It is characterized by behaviors that include one or more of the following: impaired control over drug use, compulsive use, continued use despite harm, and craving. Drug addiction is a treatable disease, using a multidisciplinary approach, but relapse is common.

Studies of abuse potential in former drug abusers found that the effects of single doses of Ambien (zolpidem tartrate) 40 mg were similar, but not identical, to diazepam 20 mg, while zolpidem tartrate 10 mg was difficult to distinguish from placebo.

Sedative/hypnotics have produced withdrawal signs and symptoms following abrupt discontinuation. These reported symptoms range from mild dysphoria and insomnia to a withdrawal syndrome that may include abdominal and muscle cramps, vomiting, sweating, tremors, and convulsions. The U.S. clinical trial experience from zolpidem does not reveal any clear evidence for withdrawal syndrome. Nevertheless, the following adverse events included in DSM-III-R criteria for uncomplicated sedative/hypnotic withdrawal were reported during U.S. clinical trials following placebo substitution occurring within 48 hours following last zolpidem treatment: fatigue, nausea, flushing, lightheadedness, uncontrolled crying, emesis, stomach cramps, panic attack, nervousness, and abdominal discomfort. These reported adverse events occurred at an incidence of 1% or less. However, available data cannot provide a reliable estimate of the incidence, if any, of dependence during treatment at recommended doses. Rare post-marketing reports of abuse, dependence and withdrawal have been received.

Because persons with a history of addiction to, or abuse of, drugs or alcohol are at increased risk of habituation and dependence, they should be under careful surveillance when receiving zolpidem or any other hypnotic.

OVERDOSAGE

Signs and symptoms: In European postmarketing reports of overdose with zolpidem alone, impairment of consciousness has ranged from somnolence to light coma. There was one case each of cardiovascular and respiratory compromise. Individuals have fully recovered from zolpidem tartrate overdoses up to 400 mg (40 times the maximum recommended dose). Overdose cases involving multiple CNS-depressant agents, including zolpidem, have resulted in more severe symptomatology, including fatal outcomes.

Recommended treatment: General symptomatic and supportive measures should be used along with immediate gastric lavage where appropriate. Intravenous fluids should be administered as needed. Flumazenil may be useful. As in all cases of drug overdose, respiration, pulse, blood pressure, and other appropriate signs should be monitored and general supportive measures employed.

Hypotension and CNS depression should be monitored and treated by appropriate medical intervention. Sedating drugs should be withheld following zolpidem overdose, even if excitation occurs. The value of dialysis in the treatment of overdose has not been determined, although hemodialysis studies in patients with renal failure receiving therapeutic doses have demonstrated that zolpidem is not dialyzable.

Poison control center: As with the management of all overdose, the possibility of multiple drug ingestion should be considered. The physician may wish to consider contacting a poison control center for up-to-date information on the management of hypnotic drug product overdose.

DOSAGE AND ADMINISTRATION

The dose of Ambien should be individualized. The recommended dose for adults is 10 mg immediately before bedtime. Downward dosage adjustment may be necessary when Ambien is administered with agents having known CNS-depressant effects because of the potentially additive effects.

Elderly or debilitated patients may be especially sensitive to the effects of Ambien (zolpidem tartrate). Patients with hepatic insufficiency do not clear the drug as rapidly as normals. An initial 5-mg dose is recommended in these patients (see *Precautions*).

The total Ambien dose should not exceed 10 mg.

sanofi-aventis U.S. LLC
Bridgewater, NJ 08807

Ambien®
(zolpidem tartrate)

Printed in USA

Brief Summary of Prescribing Information Revised June 2006

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INFORMATION FOR PATIENTS

Ambien CR™ (zolpidem tartrate extended-release) tablets



INFORMATION FOR PATIENTS TAKING AMBIEN CR

Your doctor has prescribed Ambien CR to help you sleep. The following information is intended to guide you in the safe use of this medicine. It is not meant to take the place of your doctor's instructions. If you have any questions about Ambien CR tablets be sure to ask your doctor or pharmacist.

Ambien CR is used to treat different types of sleep problems, such as:

- trouble falling asleep
- waking up often during the night

Some people may have more than one of these problems.

Ambien CR belongs to a group of medicines known as the "sedative/hypnotics", or simply, sleep medicines. There are many different sleep medicines available to help people sleep better. Sleep problems are usually temporary, requiring treatment for only a short time, usually 1 or 2 days up to 1 or 2 weeks. Some people have chronic sleep problems that may require more prolonged use of sleep medicine. However, you should not use these medicines for long periods without talking with your doctor about the risks and benefits of prolonged use.

SIDE EFFECTS

Most common side effects:

- headache
- somnolence (sleepiness)
- dizziness

You may find that these medicines make you sleepy during the day. How drowsy you feel depends upon how your body reacts to the medicine, which sleep medicine you are taking, and how large a dose your doctor has prescribed. Daytime drowsiness is best avoided by taking the lowest dose possible that will still help you sleep at night. Your doctor will work with you to find the dose of Ambien CR that is best for you.

To manage these side effects while you are taking this medicine:

- When you first start taking Ambien CR or any other sleep medicine until you know whether the medicine will still have some carryover effect in you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
- NEVER drink alcohol while you are being treated with Ambien CR or any sleep medicine. Alcohol can increase the side effects of Ambien CR or any other sleep medicine.
- Do not take any other medicines without asking your doctor first. This includes medicines you can buy without a prescription. Some medicines can cause drowsiness and are best avoided while taking Ambien CR.
- Always take the exact dose of Ambien CR prescribed by your doctor. Never change your dose without talking to your doctor first.

SPECIAL CONCERNS

There are some special problems that may occur while taking sleep medicines.

Memory problems: Sleep medicines may cause a special type of memory loss or "amnesia." When this occurs, a person may not remember what has happened for several hours after taking the medicine. This is usually not a problem since most people fall asleep after taking the medicine.

Memory loss can be a problem, however, when sleep medicines are taken while traveling, such as during an airplane flight and the person wakes up before the effect of the medicine is gone. This has been called "traveler's amnesia."

Be sure to talk to your doctor if you think you are having memory problems. Although memory problems are not very common while taking Ambien CR, in most instances, they can be avoided if you take Ambien CR only when you are able to get a full night's sleep (7 to 8 hours) before you need to be active again.

Tolerance: When sleep medicines are used every night for more than a few weeks, they may lose their effectiveness to help you sleep. This is known as "tolerance". Sleep medicines should, in most cases, be used only for short periods of time, such as 1 or 2 days and generally no longer than 1 or 2 weeks. If your sleep problems continue, consult your doctor, who will determine whether other measures are needed to overcome your sleep problems.

Dependence: Sleep medicines can cause dependence, especially when these medicines are used regularly for longer than a few weeks or at high doses. Some people develop a need to continue taking their medicines. This is known as dependence or "addiction."

When people develop dependence, they may have difficulty stopping the sleep medicine. If the medicine is suddenly stopped, the body is not able to function normally and unpleasant symptoms may occur (see *Withdrawal*). They may find that they have to keep taking the medicines either at the prescribed dose or at increasing doses just to avoid withdrawal symptoms.

All people taking sleep medicines have some risk of becoming dependent on the medicine. However, people who have been dependent on alcohol or other drugs in the past may have a higher chance of becoming addicted to sleep medicines. This possibility must be considered before using these medicines for more than a few weeks.

If you have been addicted to alcohol or drugs in the past, it is important to tell your doctor before starting Ambien or any sleep medicine.

Withdrawal: Withdrawal symptoms may occur when sleep medicines are stopped suddenly after being used daily for a long time. In some cases, these symptoms can occur even if the medicine has been used for only a week or two.

In mild cases, withdrawal symptoms may include unpleasant feelings. In more severe cases, abdominal and muscle cramps, vomiting, sweating, shakiness, and rarely, seizures may occur. These more severe withdrawal symptoms are very uncommon.

Another problem that may occur when sleep medicines are stopped is known as "rebound insomnia." This means that a person may have more trouble sleeping the first few nights after the medicine is stopped than before starting the medicine. If you should experience rebound insomnia, do not get discouraged. This problem usually goes away on its own after 1 or 2 nights.

If you have been taking Ambien CR or any other sleep medicine for more than 1 or 2 weeks, do not stop taking it on your own. Always follow your doctor's directions.

Changes in behavior and thinking: Some people using sleep medicines have experienced unusual changes in their thinking and/or behavior. These effects are not common. However, they have included:

- more outgoing or aggressive behavior than normal
- confusion
- strange behavior
- agitation
- hallucinations
- worsening of depression
- suicidal thoughts

How often these effects occur depends on several factors, such as a person's general health, the use of other medicines, and which sleep medicine is being used.

It is also important to realize that it is rarely clear whether these behavior changes are caused by the medicine, an illness, or occur on their own. In fact, sleep problems that do not improve may be due to illnesses that were present before the medicine was used. If you or your family notice any changes in your behavior, or if you have any unusual or disturbing thoughts, call your doctor immediately.

Pregnancy: Sleep medicines may cause sedation of the unborn baby when used during the last weeks of pregnancy.

Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, or if you become pregnant while taking Ambien CR.

SAFE USE OF SLEEPING MEDICINES

To ensure the safe and effective use of Ambien CR or any other sleep medicine, you should observe the following cautions:

1. Ambien CR is a prescription medicine and should be used ONLY as directed by your doctor. Follow your doctor's instructions about how to take, when to take, and how long to take Ambien CR. Ambien CR tablets should not be divided, crushed, or chewed, and must be swallowed whole.
2. Never use Ambien CR or any other sleep medicine for longer than directed by your doctor.
3. If you notice any unusual and/or disturbing thoughts or behavior during treatment with Ambien CR or any other sleep medicine, contact your doctor.
4. Tell your doctor about any medicines you may be taking, including medicines you may buy without a prescription. You should also tell your doctor if you drink alcohol. DO NOT use alcohol while taking Ambien CR or any other sleep medicine.
5. Do not take Ambien CR unless you are able to get a full night's sleep before you must be active again. For example, Ambien CR should not be taken on an overnight airplane flight of less than 7 to 8 hours since "traveler's amnesia" may occur.
6. Do not increase the prescribed dose of Ambien CR or any other sleep medicine unless instructed by your doctor.
7. When you first start taking Ambien CR or any other sleep medicine, until you know whether the medicine will still have some carryover effect in you the next day, use extreme care while doing anything that requires complete alertness, such as driving a car, operating machinery, or piloting an aircraft.
8. Be aware that you may have more sleeping problems the first night after stopping Ambien CR or any other sleep medicine.
9. Be sure to tell your doctor if you are pregnant, if you are planning to become pregnant, or if you become pregnant while taking Ambien CR or any other sleep medicine.
10. As with all prescription medicines, never share Ambien CR or any other sleep medicine with anyone else. Always store Ambien CR or any other sleep medicine in the original container that you received it in and store it out of reach of children.
11. Ambien CR works very quickly. You should only take Ambien CR right before going to bed and are ready to go to sleep.

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Scientists break code to create impeccably brilliant cut jewelry with even more clarity and color dispersion than mined diamonds.

There is little doubt that a natural mined diamond of top quality is one of the world's most magnificent gems. It is much coveted for its exquisite beauty, but the simple truth is that diamonds are just compressed crystallized carbon. The laboratories at DiamondAura were created with one mission in mind: *Create brilliant cut DiamondAura jewelry in precious metal settings that allow everyone to experience jewelry with superb clarity and large carat weight.*

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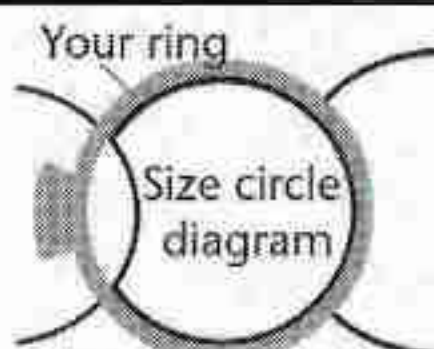
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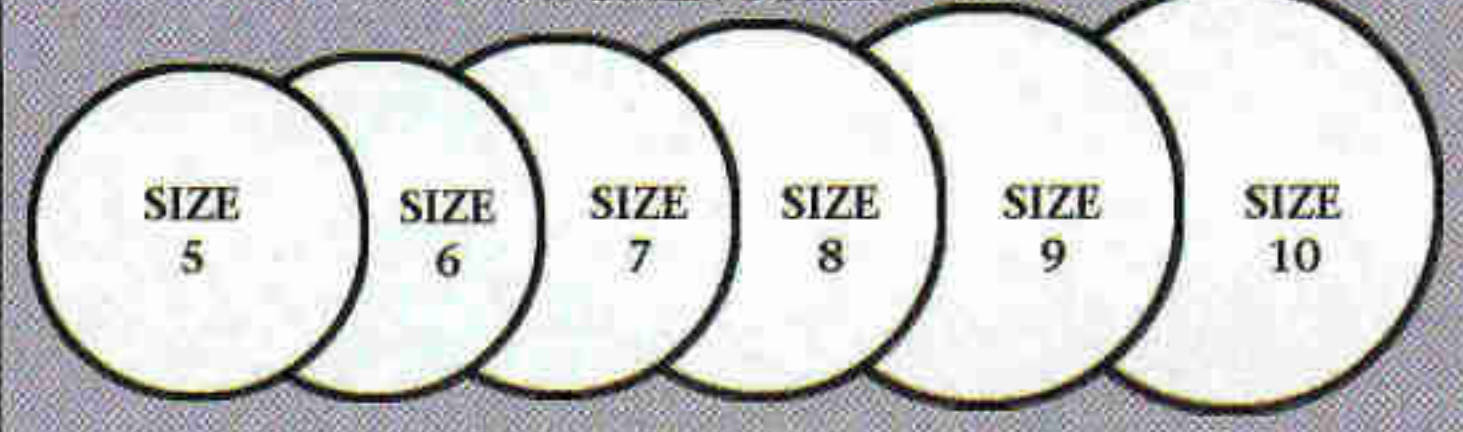
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Place one of your own rings on top of one of the circle diagrams. Your ring size is the circle that matches the inside diameter of your ring. If your ring falls between sizes, order the next larger size.



WOMEN'S SIZES





Salar de Uyuni, Bolivia Salt dug from the world's largest salt plain waits for transport to surrounding Andean villages. It's one of the flattest places on Earth; relief varies by less than 16 inches across some 4,000 square miles.

PHOTO: KAZUYOSHI NOMACHI

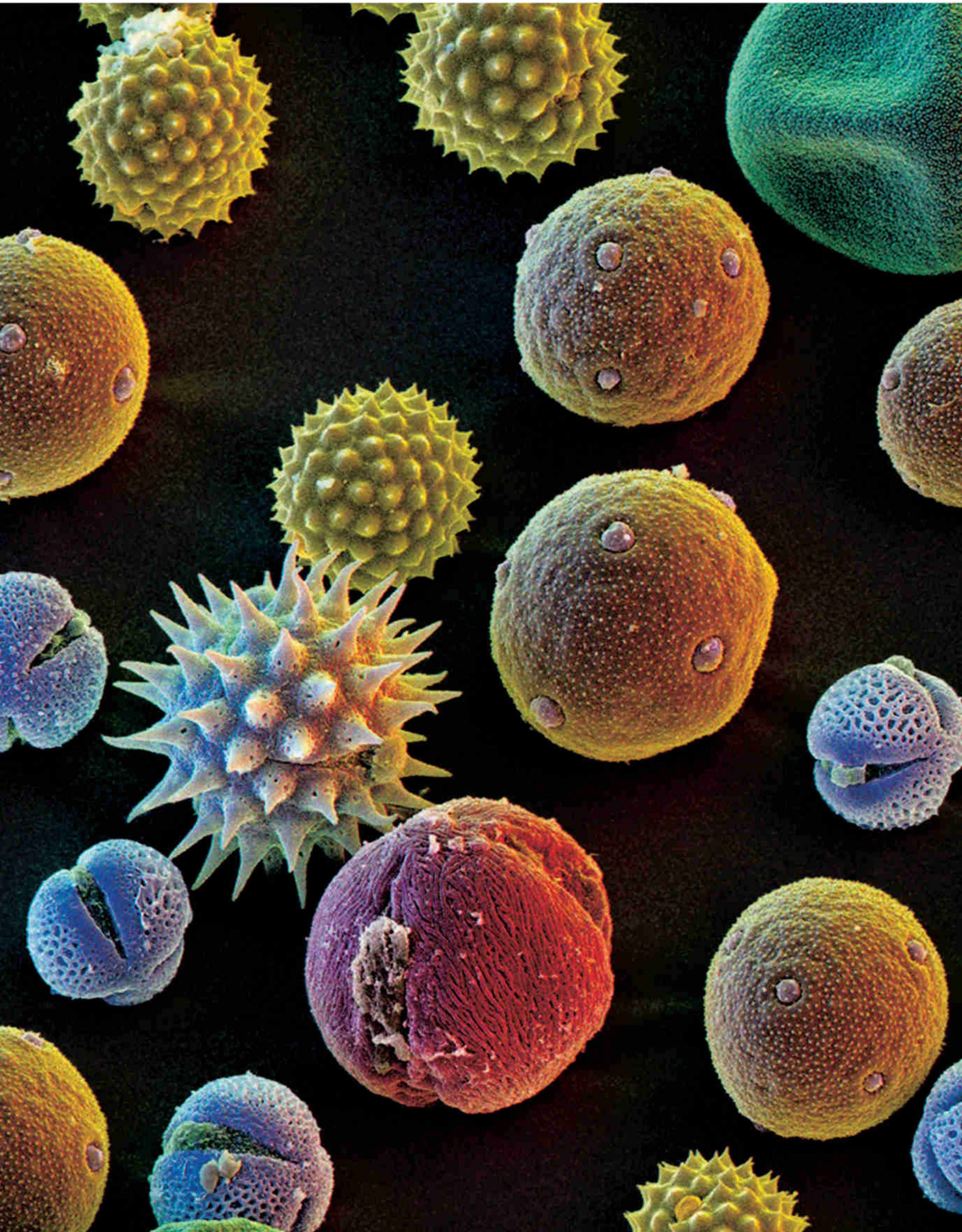


Binche, Belgium The town of Binche takes its Mardi Gras silliness seriously. The face of parade character "Gilles," below, is an internationally protected trademark. Only parade marchers may buy the wax masks.



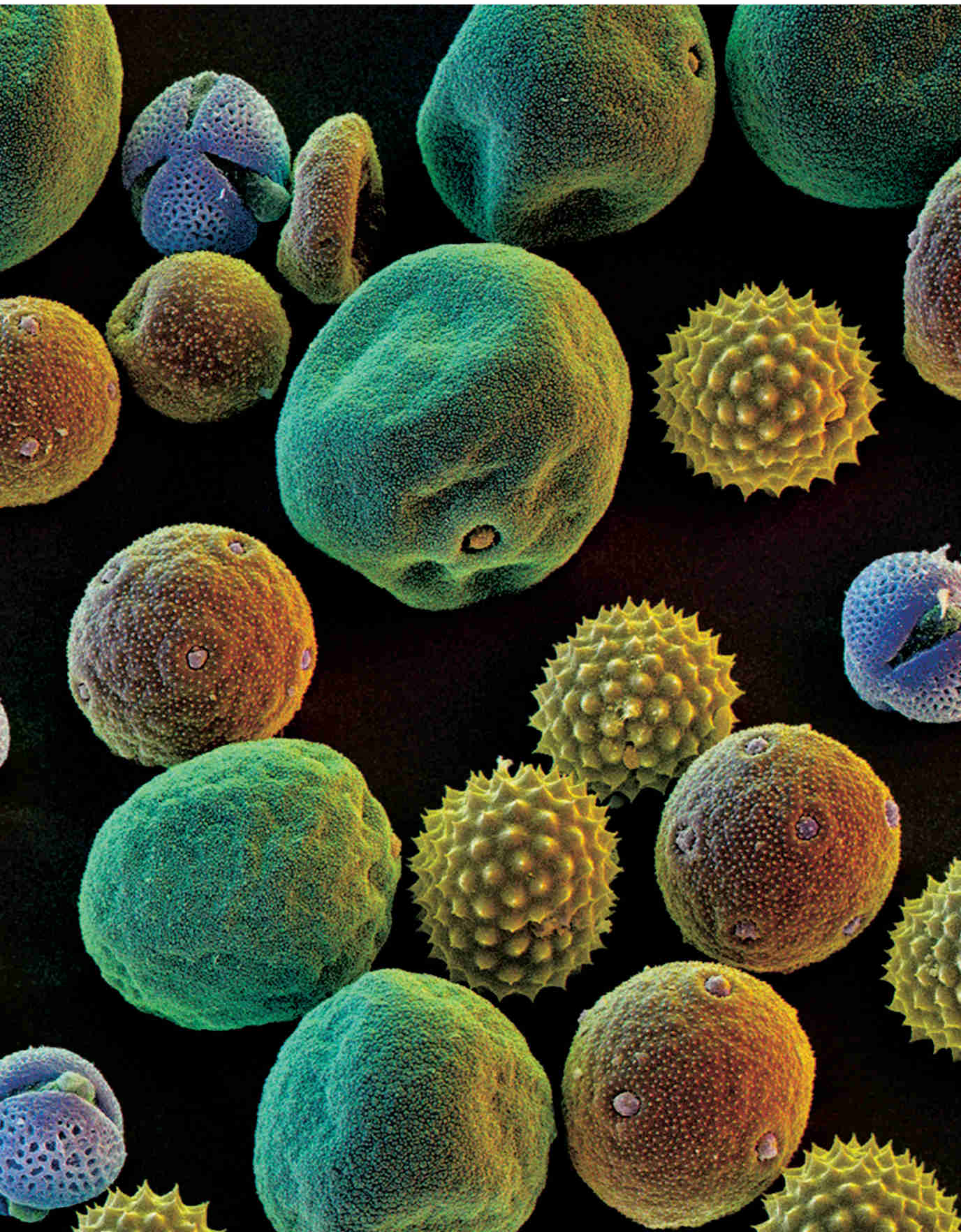


Los Angeles, California This colorized scanning electron micrograph shows pollens—Bermuda grass in green, maple in red, and ragweed in yellow—at roughly 3,000 times their itchy, sneezy life size.



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PHOTO: DAVID SCHARF, GETTY





Medusa takes center stage during Carnival in Port-of-Spain on the island of Trinidad.



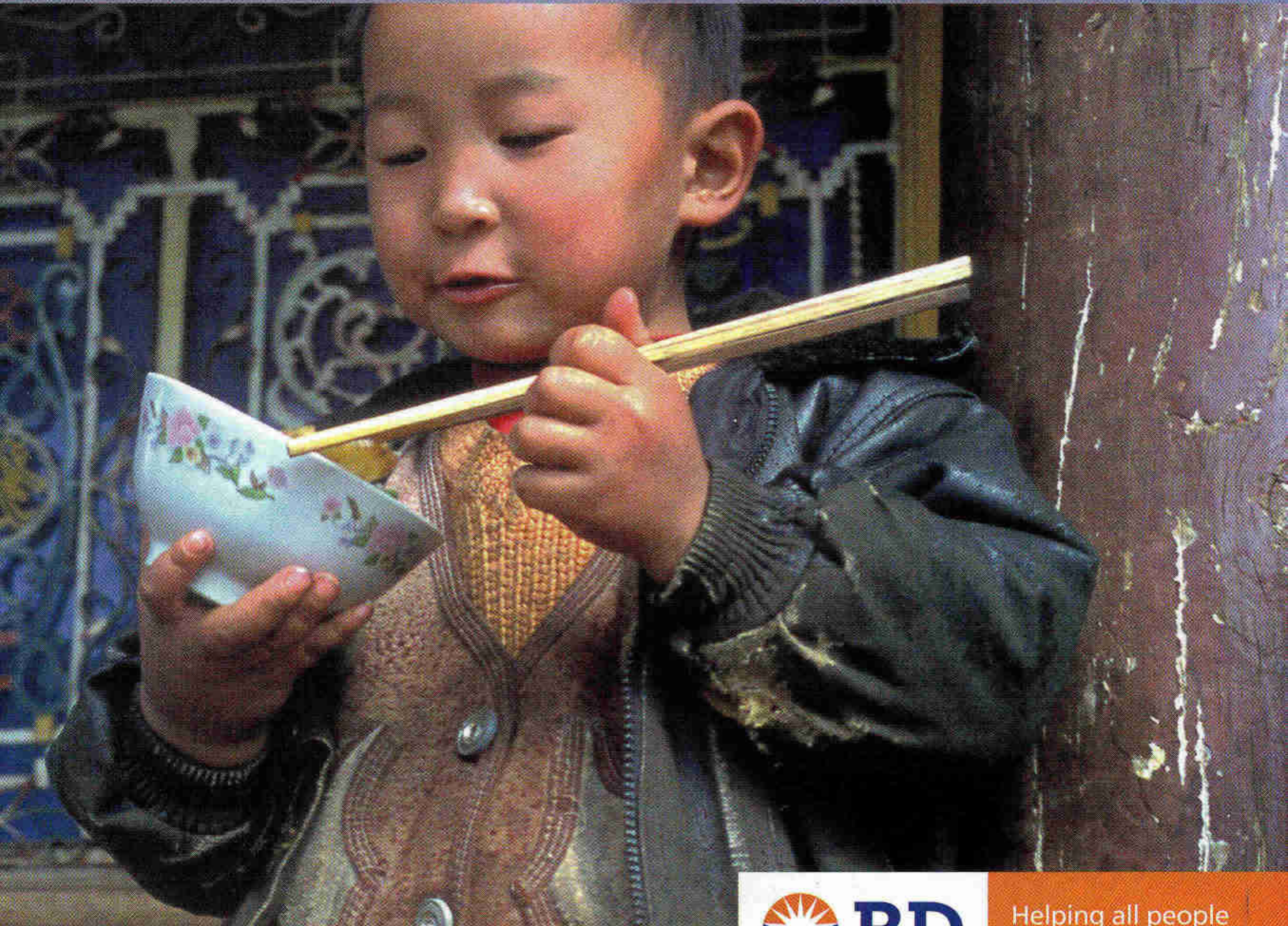
World Party In one last blast, revelers in many countries indulge in a riot of sensual pleasures before the austere observance of Christian Lent. Mardi Gras, Shrove Tuesday, Carnival, Carnaval, Carnevale—by whatever name, the celebrations sizzle with music, dancing, extravagant costumes, and wild parades. New Orleans, Rio de Janeiro, Venice, and Port-of-Spain host the biggest bacchanals. —A. R. Williams

	NEW ORLEANS	RIO DE JANEIRO	VENICE	PORT-OF-SPAIN
HISTORY	Louisiana Mardi Gras celebrations in the 1700s imitated the masked balls of Paris. Parades began in the 1800s.	Revelers hurled food and liquid at each other in a raucous street fight before parades became the rage in the mid-1800s.	Carnevale's origins reach back to the 11th century. Celebrations died out after Venice's 1797 fall to Napoleon but revived in 1980.	French planters brought Carnival with them in the 18th century. It was taken up by former slaves after their 1834 emancipation.
FOOD	King cake, iced in gold, purple, and green. Whoever gets the tiny doll baked inside is obligated to host the next party.	<i>Bolinos de bacalhau</i> (cod fritters), <i>feijoada</i> (meat and bean stew), manioc fries, <i>caipirinha</i> (sugarcane liquor, lime, sugar)	<i>Frittelle</i> (fritters), <i>crepelle</i> (crepes), <i>sfingi</i> and <i>galani</i> (doughnuts), <i>berlingaccio</i> (sweet bread), <i>sanguinaccio</i> (blood pudding)	<i>Pelau</i> (chicken, rice, and pigeon peas), bake and shark (fish sandwich), doubles (curried chickpeas in fried dough), rum
RITUALS	Masked balls, parades of floats, jazz brass bands, throwing beads and doubloons to the crowds	Formal balls, and a parade of floats and thousands of samba dancers through the Sambadrome	Masked balls, parades, processions of gondolas, pantomimes, juggling, fireworks, concerts	The Carnival season of parties, concerts, and steel band shows climaxes in two days of parades.
DID YOU KNOW?	Social clubs, or krewes, organize parades and balls. The oldest, Mistick Krewe of Comus, began in 1857. The first African-American club, Zulu, was founded in 1909.	Kicking off Carnaval in 2006, a free Rolling Stones concert drew more than a million fans to Copacabana Beach.	At the height of the 10-day festival, some 150,000 visitors a day flock to the city's historic center, home to 62,000 Venetians.	Soca, the soul-influenced calypso sound native to Trinidad and Tobago, propels Carnival parades with a pounding rhythm.



In 1983, at the invitation of China's Ministry of Health and university medical centers, Project HOPE became the first private international health organization to make a long-term commitment to improving that vast nation's healthcare system.

Recently, Project HOPE's China Diabetes Program was launched to increase both public and professional awareness of diabetes and improve the quality and availability of diabetes care. To learn more, visit www.projecthope.org.



Helping all people
live healthy lives

Partners in health

More than 30 million people in China are living with a disease they know little or nothing about. Diabetes, known for decades in many countries as the "silent killer," rapidly has become a major chronic disease for the Chinese.¹

Project HOPE and its partners are combining education with public awareness campaigns to slow the spread of the disease.

The ultimate goal of the partnership is to train Chinese nurses, physicians, and dieticians so they, in turn, can train staff and medical professionals. To date, more than 170,000 individuals in 32 Chinese provinces have received training.

Since the development of the BD glass syringe for insulin delivery in 1924, BD has been a major provider of healthcare devices and educational

programs for health professionals and diabetes sufferers. It was natural, then, for BD to partner with Project HOPE and share its expertise and financial support with the China Diabetes Program.

BD is a medical technology company serving some of the greatest needs of the global community. Healthcare institutions, life sciences researchers, clinical laboratories, industry, and the general public all rely on BD products every day.

BD—selected as one of America's Most Admired Companies by *FORTUNE* magazine²—is privileged to partner with Project HOPE and organizations like it to protect life by addressing fundamental healthcare issues in every corner of the world.

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² *Diabetes Care*, 2004; World Health Organization.

³ "America's Most Admired Companies" annual survey, 2005; *FORTUNE* magazine, March 7, 2005.

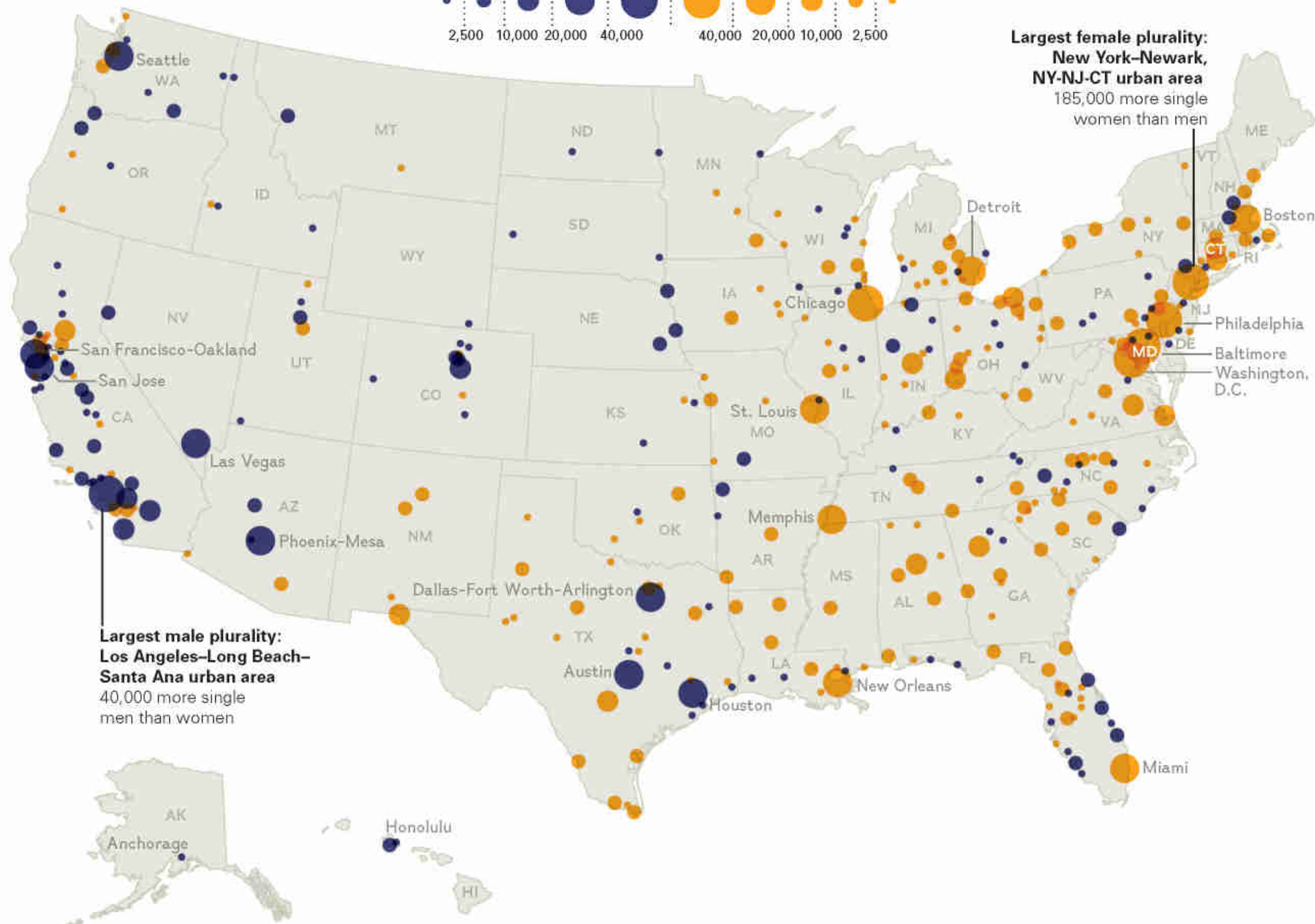
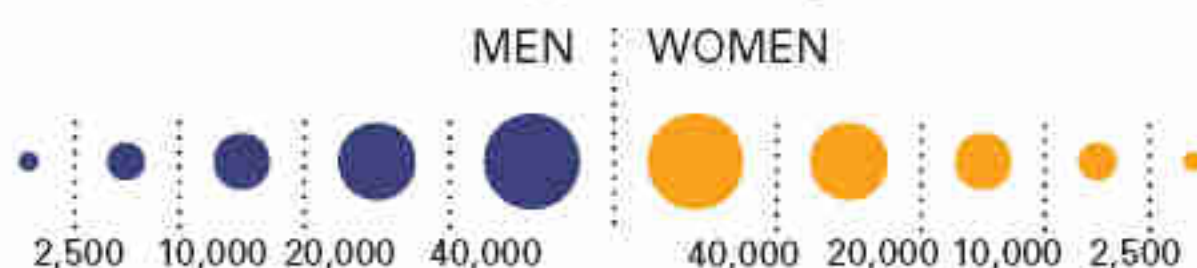
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Singles

Color indicates whether there are more single men or women.

more men ● ● more women

Size indicates how many more single men or women.



Largest female plurality:
 New York–Newark,
 NY–NJ–CT urban area
 185,000 more single
 women than men

Largest male plurality:
 Los Angeles–Long Beach–
 Santa Ana urban area
 40,000 more single
 men than women

Single and looking? Lonely singles' chances of finding mates are influenced by which side of the Mississippi River they live on, according to the U.S. Census Bureau. Western urban areas tend to boast an excess of single males, while many eastern cities feature a preponderance of females. Demographers say a few key factors shape this trend; notably, 58 percent of college students are women, giving most of the East's numerous college towns a female majority. After graduating, legions of these women join the white-collar workforce, which is 51 percent female and centered in big cities such as New York, Chicago, and Washington, D.C. Areas with more single men often have large numbers of illegal immigrants, some 58 percent of whom are male and generally work either in districts that rely on agriculture or in cities with booming construction sectors, such as Las Vegas. —Peter Gwin



AFRICA
ALASKA
ASIA & PACIFIC
AUSTRALIA
NEW ZEALAND
CANADA
NEW ENGLAND
CARIBBEAN
EUROPE
HAWAII
MEXICO
PANAMA CANAL
SOUTH AMERICA
WORLD VOYAGE



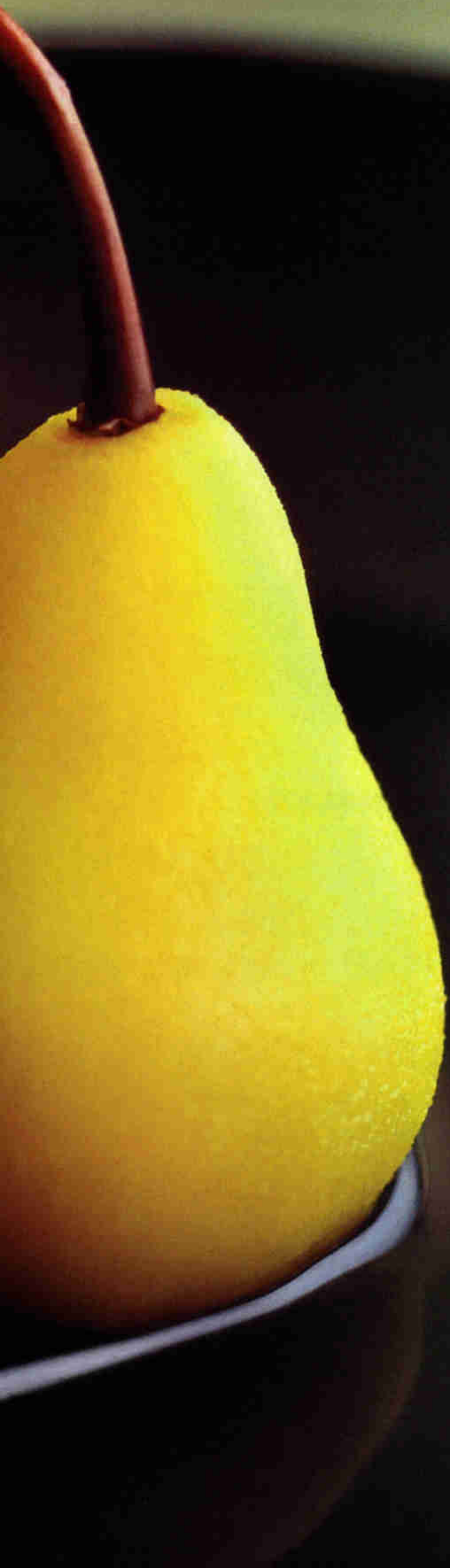
Intrigue your senses.

We invite you to feast. To captivate not only your palate, but your eyes as well. To dine in a manner not easily forgotten; to release your inner sous-chef; to indulge the notion to have breakfast appear daily on your private verandah. We invite your senses to be delighted, time and again, in ways large and small. We invite you, and we are at your service. Call your Travel Professional or 1-877-SAIL HAL or visit www.hollandamerica.com.



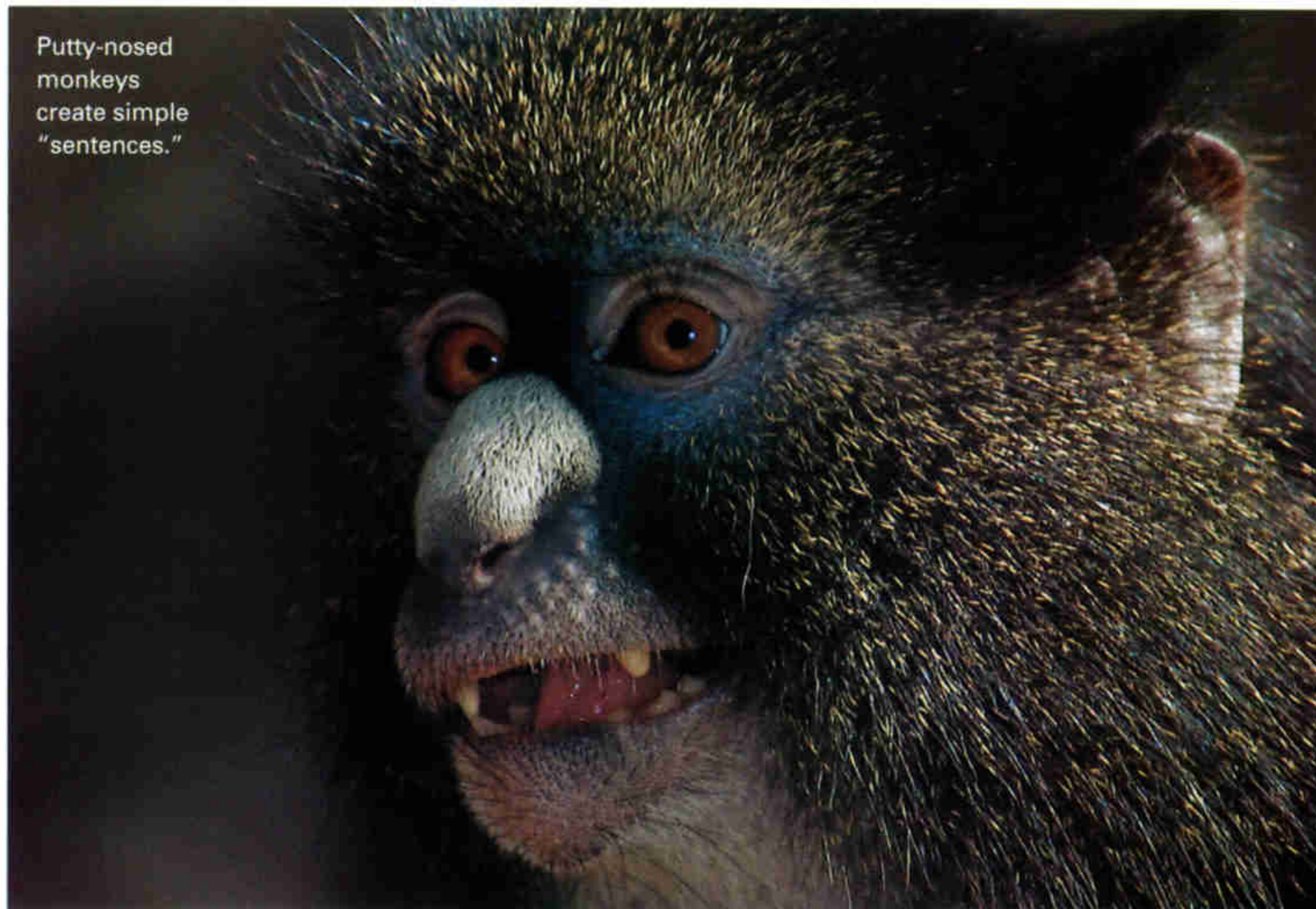
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Sublime

Putty-nosed monkeys create simple "sentences."



Monkey Talk Many animals have been observed using simple vocal signals among themselves. Now for the first time, scientists believe they have evidence of a nonhuman mammal combining signals to create entirely new meanings. Male putty-nosed monkeys in Nigeria have been observed stringing together calls of *pyow* and *hack*. Males of many monkey species commonly repeat *pyow* or *hack* for warning females and their young charges. Used alone, the calls mean a predator may be ready to attack, says researcher Klaus Zuberbühler. In sequence as the putty-nosed monkeys use them, he says, there might not be a specific danger, just the male's urge to get moving. —Chris Carroll

Putty-nosed monkeys repeat basic calls to sound an alarm:

- **Pyow** A leopard or other predator is lurking nearby.
- **Hack** An airborne predator, such as an eagle, is close.

They combine the calls to create a simple "sentence":


- **Pyow pyow hack hack hack hack.** Let's leave this place and go elsewhere.

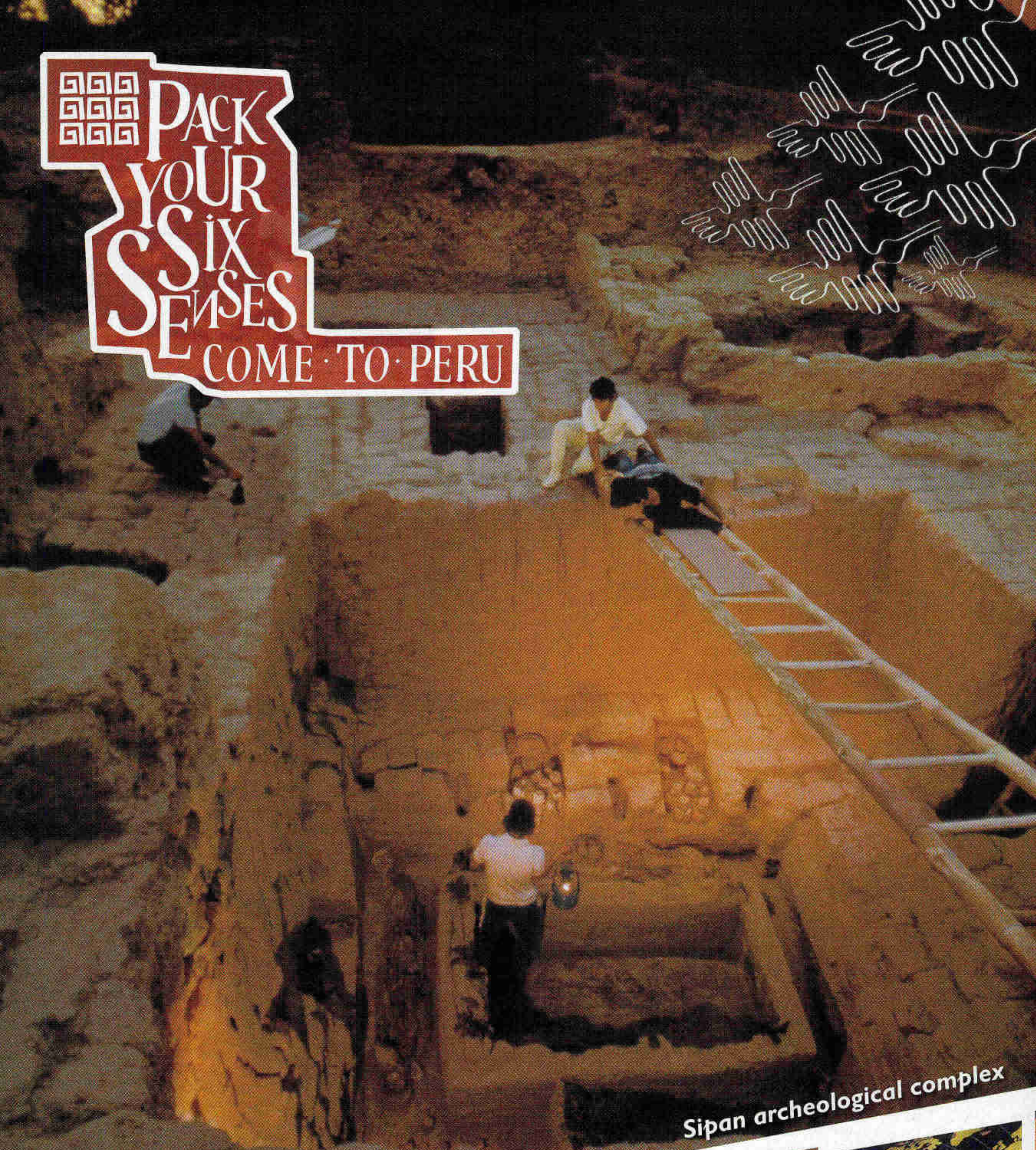
Animal Watch

Like any group house, honeybee hives can get too crowded. When a hive is simply bursting, the honeybee residents engage in a collective decision process that could inspire even the best-run commune. The queen and about half the hive fly to a tree and wait while scouts fan out to look for a new home. According to a study published in *American*

Scientist, scouts that find good nesting spots compete against each other to recruit undecided scouts to their sites by doing a "waggle dance." Recruits will then inspect the site for themselves. If they like the spot, they too will waggle dance to advertise it. Once 15 or more scouts converge on a single site, they return to their queen and

waiting hive mates. The scouts then press their vibrating thoraxes against the waiting bees to warm up the latter for flight. When all are ready, the whole group flies to its new home. The study notes that because each scout judges a site independently, only truly good sites attract more waggle dancers and end up being chosen by the group.

 **PACK
YOUR
SIX
SENSES**
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Sipán archeological complex

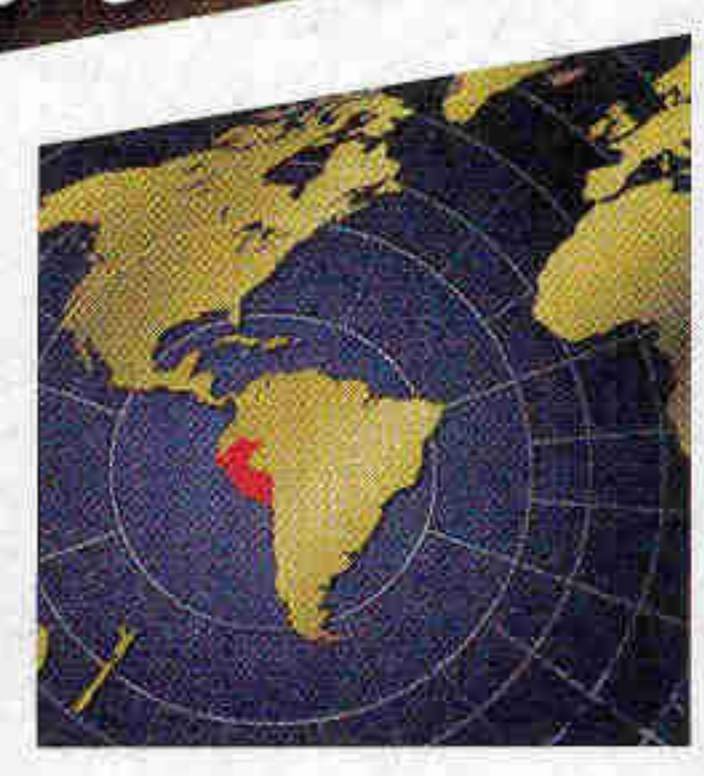
Magical Archaeology

Sipán: More than just the spectacular nature of the discovery and the sterling quality of the relics, the Royal Tombs of the Lord of Sipán have enabled historians and archaeologists to piece together much of the lost history of an impressive civilization which dominated most of northern Peru for centuries: the Moche.

After spending years on exhibit in the Americas, Europe and Asia, the treasures of the Lord of Sipán are now on display at the Museum "Tumbas Reales de Sipán" in the town of Lambayeque.

Discover why Peru is considered by many as the heart of the greatest civilizations in South America.

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There is something for everyone to do and see in Peru. Experience a variety of climates and ecosystems. See ancient civilizations and structures that run from Paleolithic times through the Andean cultures right up to the grand reign of the Inca.



Túcume, The Valley Of The Pyramids

On the north coast, 33 kilometers north of Chiclayo, lies the Valley of the Pyramids, an architectural complex of 26 adobe pyramids (huacas). The most outstanding, Huaca Larga, is the largest in South America. Nearby you'll find the must-see Pomac Forest Historical Sanctuary, with its vibrant woodlands and own species of wildlife, and the archaeological zone of Batán Grande, where the tomb of the Lord of Sicán (Lambayeque culture) was found.



Chan Chan, The Mud Metropolis

This is the largest mud-brick settlement built by a pre-Hispanic civilization in the Americas. This 20-kilometer archaeological site was once inhabited by as many as 50,000 people in buildings housing different social classes. Its walls are heavily decorated with haute-relief geometric, mythological, and animal figures. The amazing hydraulic systems, irrigation canals, and underground aqueducts carried water great distances.



The Paracas National Reserve

The Ica region is home to The Paracas National Reserve (22 kilometers south of Pisco). This rich coastal ecosystem covers nearly 830,000 acres of breathtaking desert,

beaches, islands, and ocean. The natural habitat is a haven for penguins, sea lions, dolphins, pelicans, and flamingos. Try archaeology and nature-watching by trekking, cycling, dune buggy rides, or horseback. The Paracas is a photographer's dream.



Machu Picchu, The Lost City Of The Inca

Enveloped in a magical silence 112 kilometers northwest of Cusco lies one of the most beautiful sites on the planet. The citadel is believed to have been used for Inca religious purposes. The urban section includes temples, palaces, plazas, workshops, stairways, and fountains. Climb the Huayna Picchu (young mountain) for classic photo taking. The ascent takes one hour along a steep path. Climbers must register at the Sacred Stone section.



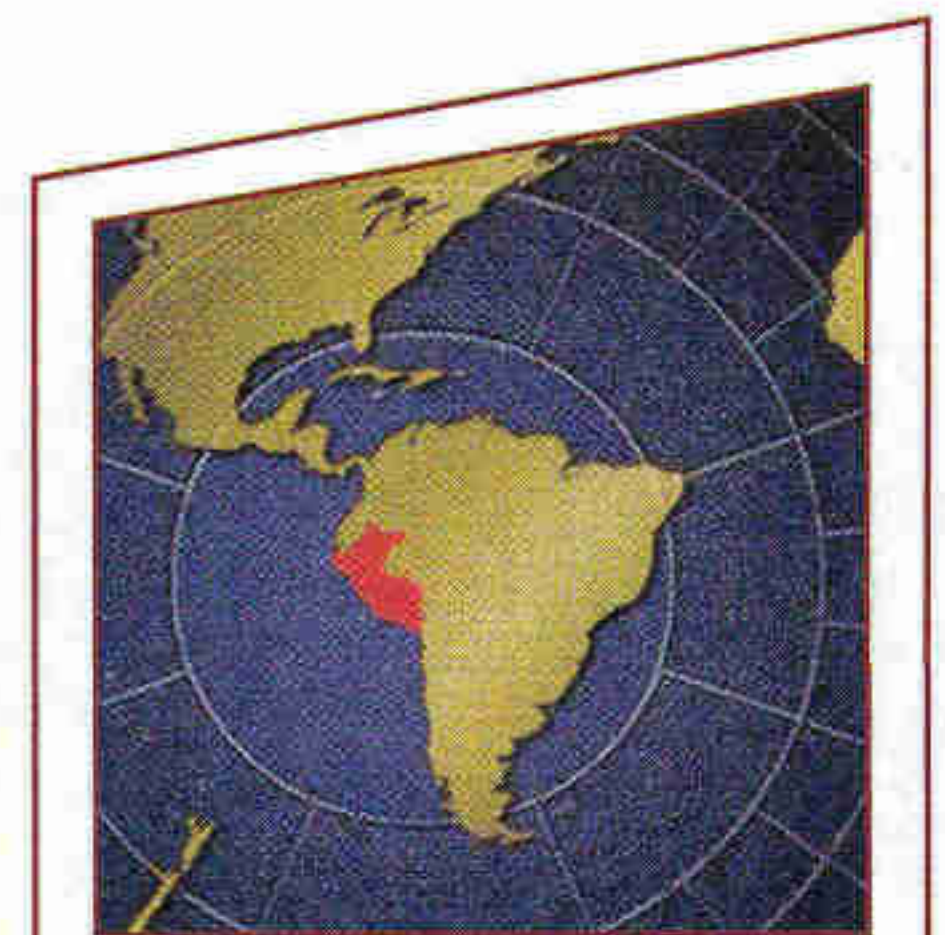
Cusco And The Sacred Valley

Cusco in the southeastern Andes is the archaeological capital of the Americas. The city's Sacred Valley of the Inca architectural legacy dates back to the 15th century. Remarkable constructions include the upper city Sacsayhuamán, the Korikancha (temple of the sun) and Hatun Rumiyoc Street (off the main square), with the wall of the famous 12-sided stone. Search for your own finds in the colorful native markets of Chinchero and Pisac.



Colca And Cotahuasi, The World's Deepest Canyons

The Arequipa region has the deepest canyons with pre-Hispanic terraces and a unique plant and animal life. The Colca (11,155 feet) has the unforgettable lookout point Cruz del Cóndor, where condors live in their natural habitat. Cotahuasi (11,598 feet) offers snowcapped mountain vistas, Luicho's hot medicinal springs, and the Sipia waterfalls. The villagers of picturesque Pampamarca and Callata are skilled at weaving alpaca wool into works of art.





Túcume, The Valley Of The Pyramids



COLOMBIA

Tumbes
TUMBES

Sullana
PIURA
Piura

Túcume
Chiclayo

Chan Chan
Trujillo



Chan Chan, The Mud Metropolis



The Paracas National Reserve



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The World's Deepest Canyons, Colca And Cotahuasi



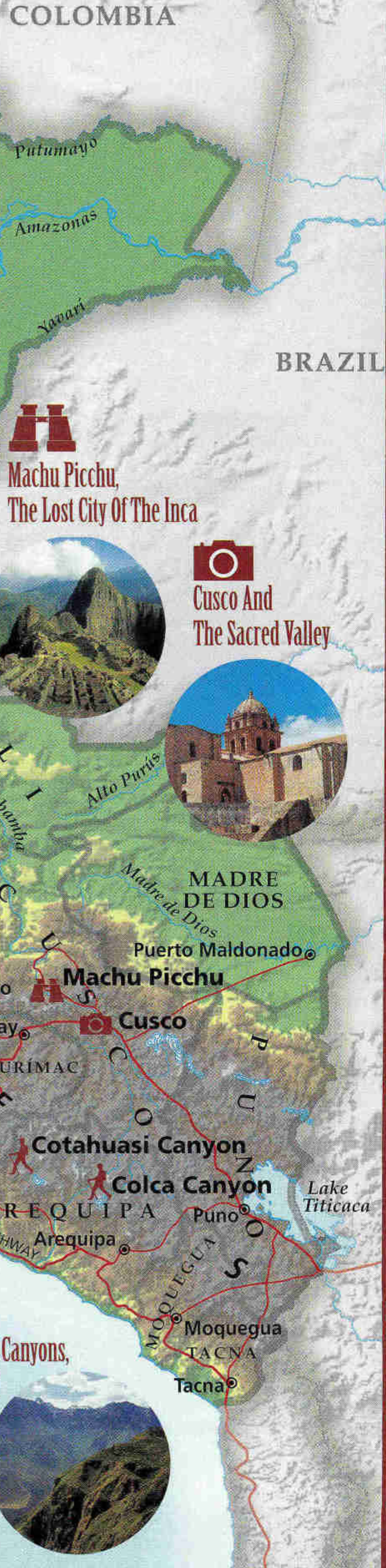
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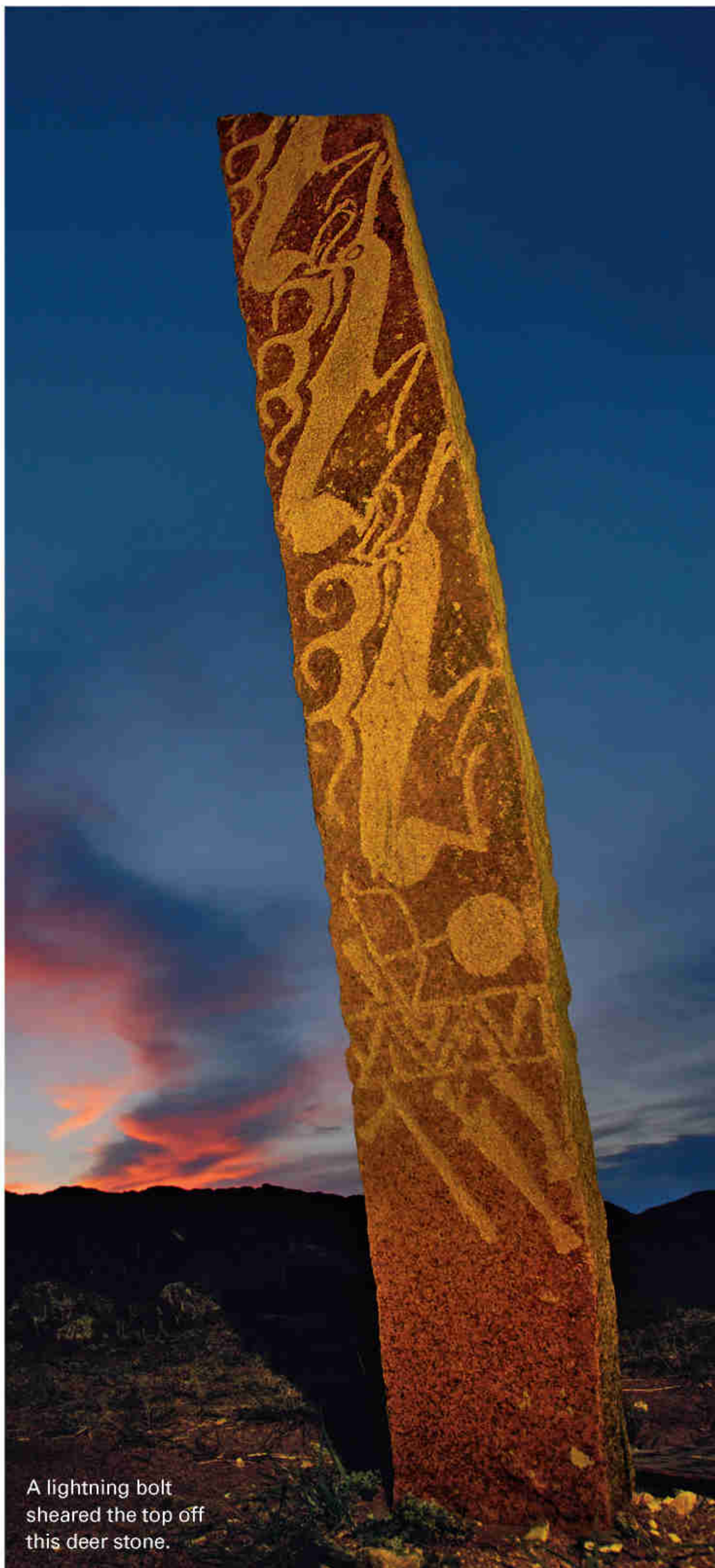


Machu Picchu, The Lost City Of The Inca



Cusco And The Sacred Valley





A lightning bolt sheared the top off this deer stone.

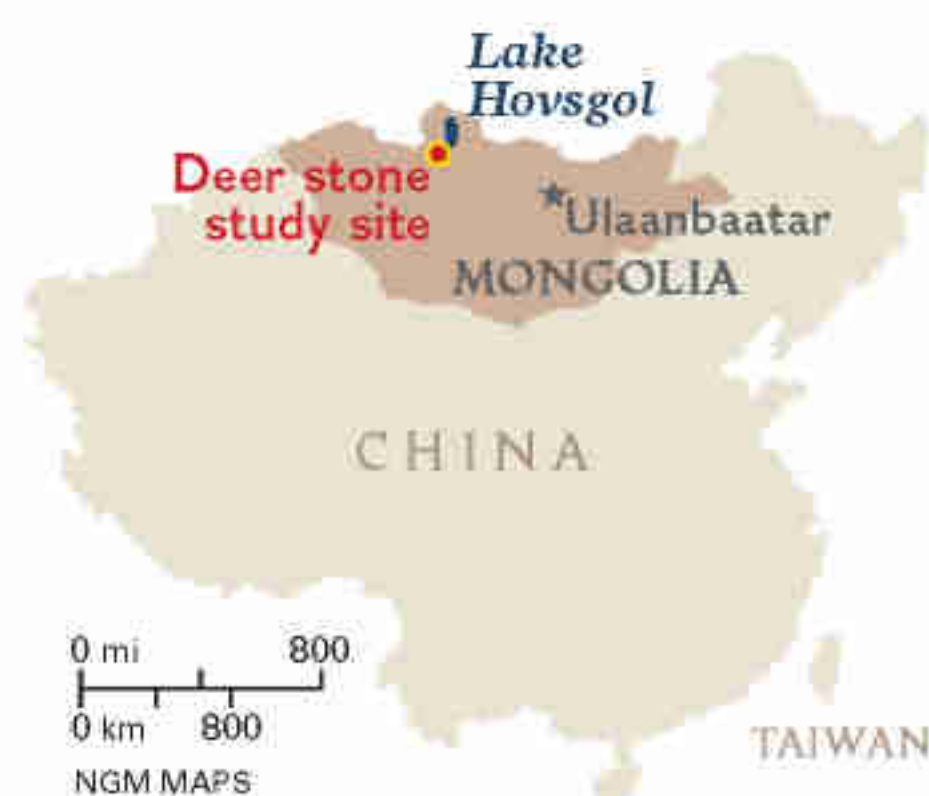
NG GRANTEE

Signposts to a Lost Culture

On Mongolia's remote northern plains, mysterious images of antlered creatures with birdlike beaks climb granite monoliths called deer stones. The slabs, some as tall as 15 feet, also depict belts hung with Bronze Age arrows, axes, and other tools. Scholars say the stones were erected between 1100 and 800 B.C., about two thousand years before Genghis Khan's horsemen dominated these plains, and are trying to decipher the stones' meaning.

"My hunch is they memorialize chiefs or warriors, maybe lost in battle," says anthropologist William Fitzhugh. He suggests the deer-bird creatures were meant to lead the way to the afterlife. The tool belt may identify an honored warrior's favored weapons. Whatever the deer stones represent, says Fitzhugh, it was important; several horses were sacrificed for each. The horse heads were buried in a ring around the slabs, typically with their noses pointing toward the rising sun.

Scholars have found some 600 deer stones so far in Mongolia, Kazakhstan, and Russia. Fitzhugh expects that figure to double with more exploration of the region. —Peter Gwin



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Street Food

Hot dogs in the U.S., maize on the cob in Tanzania, and crepes in France: In nearly every country of the world, street vendors serve up fast, cheap, tasty snacks. These are just a few.



India

Pani puri (also called *golgappa*) Potato cubes, chickpeas, and tomatoes are stuffed in a fried flour shell, then drenched in a tamarind sauce. **10 to 20 rupees (25 to 50 cents)**



Poland

Obwarzanki Bread rings, brushed with egg white to add shine, are tied together with a string to hang around the neck or wrist. **2 to 3 zlotys (65 cents to \$1)**



Mexico

Paleta de mango Pierced with a stick, then peeled and scored into sections, the fruit is sprinkled with lime juice, chili powder, and salt. **11 pesos (\$1)**



Germany

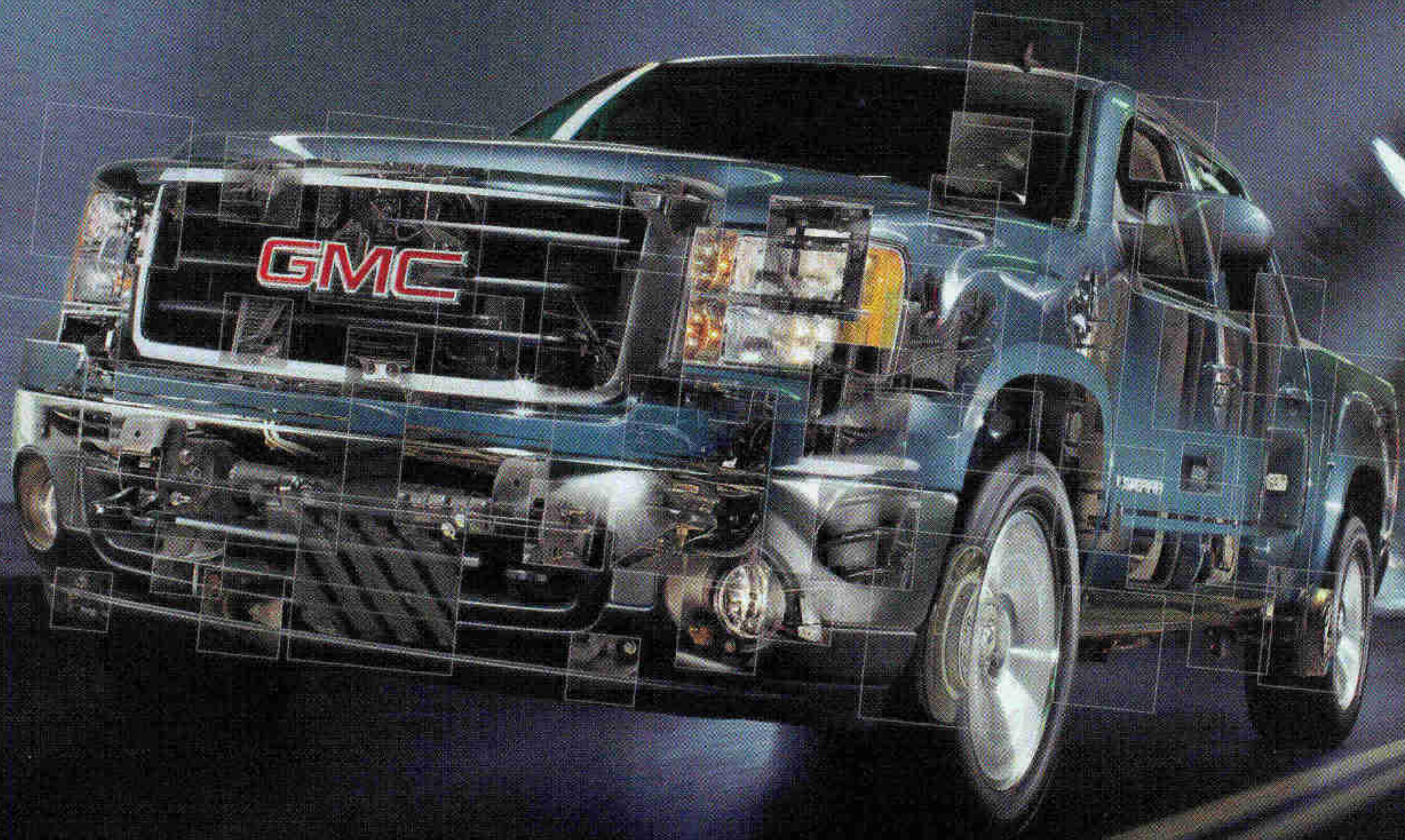
Currywurst Grilled pork sausage is sliced and topped with a few squirts of ketchup, then dusted with curry powder. It's served with a roll or fries. **2.50 euros (\$3)**



Brazil

Acarajé Fritters of mashed black-eyed peas are filled with *vatapa*, a sun-dried shrimp puree mixed with okra, tomatoes, and cilantro. **2 reals (\$1)**

WE EXAMINED EVERYTHING. AND OVERLOOKED NOTHING.



OUR ENGINEERS SCoured EVERY INCH OF THE ALL-NEW 2007 SIERRA LOOKING FOR WAYS TO IMPROVE IT.

WHERE IN THE WORLD?



The Coco River marks a sinuous boundary between Honduras and Nicaragua on the Mosquito Coast.

Farthest Shore By land, the Mosquito Coast is still a mythically remote tangle of roadless swamp and savanna (green), wide lagoons (gray), small farms, and malarial villages—a refuge for the Miskito Indians who gave the region its name. By sea, it's a territory under siege: Pirates now steal the lobsters Miskito divers once plucked from reef-studded shallows, foreign trawlers haul away fish that breed in vast sea grass beds, drug runners ferry cocaine up the coast, and illegal shippers dump toxic waste on the long, empty beaches. For centuries, the Miskito have fought invaders; they've kept the land, but they're losing the sea. —*Karen E. Lange*

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*Based on 2007 MY Sierra vs. 2006 MY Sierra. **With available 5.3L V8 engine 2WD 22 mpg HWY. †Whichever comes first. See dealer for details.
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WILDLIFE



Gonatus onyx cradles her 3,000 eggs.

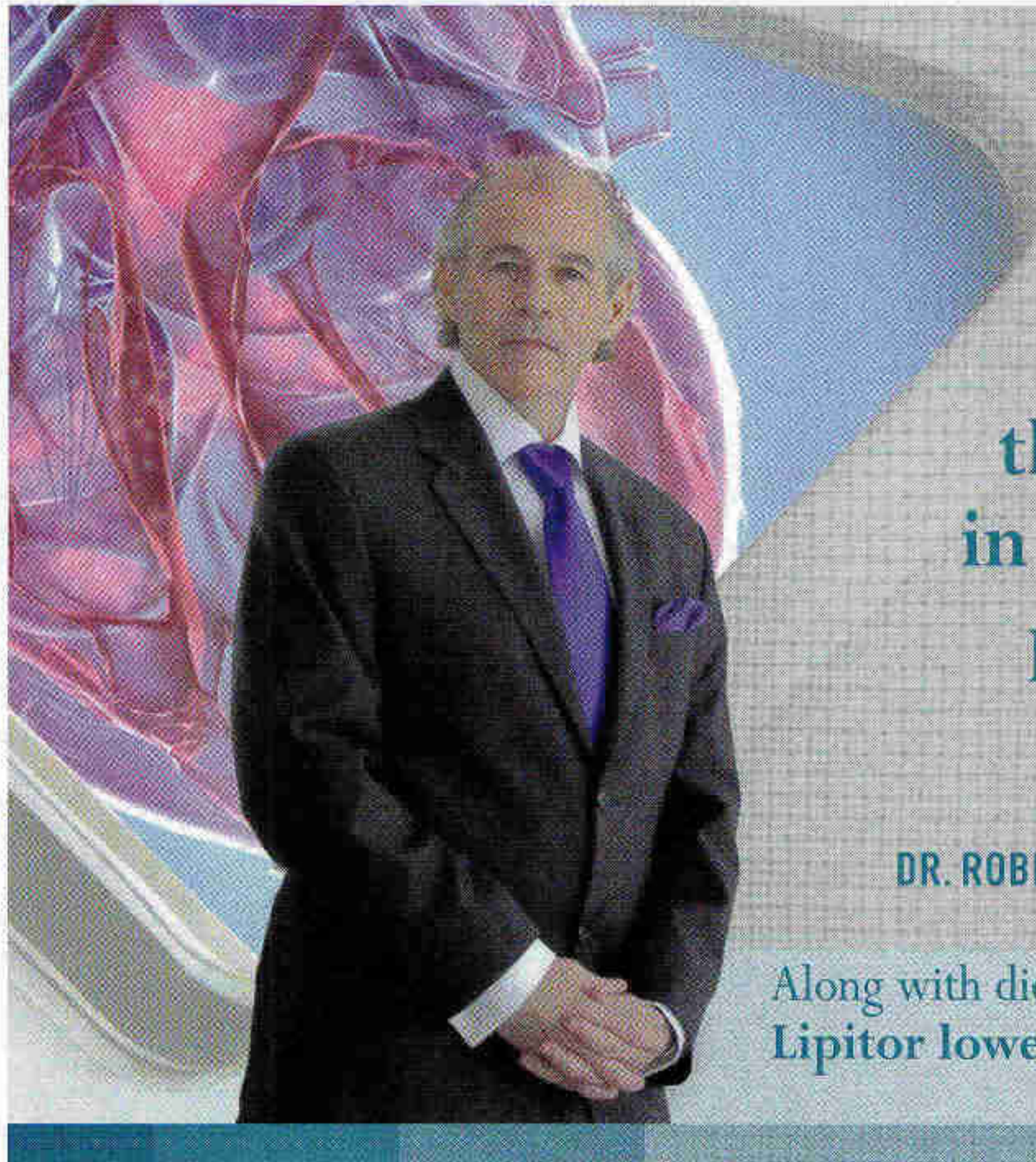
A Task for Tentacles

It's not easy doting on a family of thousands. Just ask *Gonatus onyx*, a squid species that cares for its eggs throughout their six-to-nine-month development rather than dumping them on the seafloor to fend for themselves.

Sending a remotely operated vehicle down 8,200 feet off Monterey, California, University of Rhode Island biologist Brad Seibel and colleagues at Monterey Bay Aquarium observed five mother squid cradling masses of up to 3,000 eggs each. Tiny arm hooks hold the membranous sacs in place. And the adults periodically pump the sacs open and closed, drawing in water to aerate the eggs.

In time, the strenuous care saps the adult's strength and limits her movement. But Seibel suspects the behavior is common in deep water, where predation is fairly light. Even if a mother is pursued as prey, Seibel's team found, her flight can cause the eggs to hatch, allowing at least some young to survive. —Jennifer S. Holland

▶ **Video** Watch a squid snap up prey at ngm.com/0408/feature2.



“Heart disease is
the #1 health problem
in America. Stroke is #3.
Lipitor helps reduce
the risk of both.”

DR. ROBERT JARVIK ~ INVENTOR OF THE JARVIK ARTIFICIAL HEART

Along with diet and exercise,
Lipitor lowers bad cholesterol 39-60%.*

*Average effect depending on dose

Unlike some cholesterol-lowering medications, Lipitor has been approved to reduce the risk of heart attack and stroke if you have several common risk factors for heart disease. Risk factors include family history, high blood pressure, age, low HDL (‘good’ cholesterol) or smoking.

IMPORTANT INFORMATION: LIPITOR is a prescription drug. It is used in patients with multiple risk factors for heart disease such as family history, high blood pressure, age, low HDL (‘good’ cholesterol) or smoking to reduce the risk of heart attack and stroke. When diet and exercise alone are not enough, LIPITOR is used along with a low-fat diet and exercise to lower cholesterol.

LIPITOR is not for everyone. It is not for those with liver problems. And it is not for women who are nursing, pregnant or may become pregnant. If you take LIPITOR, tell your doctor if you feel any new muscle pain or weakness. This could be a sign of rare but serious muscle side effects.

Tell your doctor about all of the medicines you take. This may help avoid serious drug interactions. Your doctor should do blood tests to check your liver function before and during treatment and may adjust your dose. The most common side effects are gas, constipation, stomach pain and heartburn. They tend to be mild and often go away.

Please see additional important information on next page.

When diet and exercise are not enough, adding LIPITOR can help. LIPITOR is one of many cholesterol-lowering treatment options that you and your doctor can consider.

Could you be doing more...with Lipitor?

Ask your doctor. Call 1-888-LIPITOR (1-888-547-4867). Or find us on the web at www.lipitor.com

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IMPORTANT FACTS



LIPITOR
atorvastatin calcium
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(LIP-ih-tore)

LOWERING YOUR HIGH CHOLESTEROL

High cholesterol is more than just a number, it's a risk factor that should not be ignored. If your doctor said you have high cholesterol, you may be at an increased risk for heart attack. But the good news is, you can take steps to lower your cholesterol.

With the help of your doctor and a cholesterol-lowering medicine like LIPITOR, along with diet and exercise, you could be on your way to lowering your cholesterol.

Ready to start eating right and exercising more? Talk to your doctor and visit the American Heart Association at www.americanheart.org.

WHO IS LIPITOR FOR?

Who can take LIPITOR:

- People who cannot lower their cholesterol enough with diet and exercise
- Adults and children over 10

Who should NOT take LIPITOR:

- Women who are pregnant, may be pregnant, or may become pregnant. LIPITOR may harm your unborn baby. If you become pregnant, stop LIPITOR and call your doctor right away.
- Women who are breast-feeding. LIPITOR can pass into your breast milk and may harm your baby.
- People with liver problems
- People allergic to anything in LIPITOR

BEFORE YOU START LIPITOR

Tell your doctor:

- About all medications you take, including prescriptions, over-the-counter medications, vitamins, and herbal supplements
- If you have muscle aches or weakness
- If you drink more than 2 alcoholic drinks a day
- If you have diabetes or kidney problems
- If you have a thyroid problem

ABOUT LIPITOR

LIPITOR is a prescription medicine. Along with diet and exercise, it lowers "bad" cholesterol in your blood. It can also raise "good" cholesterol (HDL-C).

LIPITOR can lower the risk of heart attack or stroke in patients who have risk factors for heart disease such as:

- age, smoking, high blood pressure, low HDL-C, heart disease in the family, *or*
- diabetes with risk factor such as eye problems, kidney problems, smoking, or high blood pressure

POSSIBLE SIDE EFFECTS OF LIPITOR

Serious side effects in a small number of people:

- **Muscle problems** that can lead to kidney problems, including kidney failure. Your chance for muscle problems is higher if you take certain other medicines with LIPITOR.
- **Liver problems.** Your doctor may do blood tests to check your liver before you start LIPITOR and while you are taking it.

Symptoms of muscle or liver problems include:

- Unexplained muscle weakness or pain, especially if you have a fever or feel very tired
- Nausea, vomiting, or stomach pain
- Brown or dark-colored urine
- Feeling more tired than usual
- Your skin and the whites of your eyes turn yellow

If you have these symptoms, call your doctor right away.

The most common side effects of LIPITOR are:

- Headache
- Constipation
- Diarrhea, gas
- Upset stomach and stomach pain
- Rash
- Muscle and joint pain

Side effects are usually mild and may go away by themselves. Fewer than 3 people out of 100 stopped taking LIPITOR because of side effects.

HOW TO TAKE LIPITOR

Do:

- Take LIPITOR as prescribed by your doctor.
- Try to eat heart-healthy foods while you take LIPITOR.
- Take LIPITOR at any time of day, with or without food.
- If you miss a dose, take it as soon as you remember. But if it has been more than 12 hours since your missed dose, wait. Take the next dose at your regular time.

Don't:

- Do not change or stop your dose before talking to your doctor.
- Do not start new medicines before talking to your doctor.
- Do not give your LIPITOR to other people. It may harm them even if your problems are the same.
- Do not break the tablet.

NEED MORE INFORMATION?

- Ask your doctor or health care provider.
- Talk to your pharmacist.
- Go to www.lipitor.com or call 1-888-LIPITOR.



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LPIF Rev 2, Dec 2005

Childhood Dream Brings a Fortune in Gold & Silver Lost in a Hurricane 140 Years Ago

By David Welch

Greg Stemm has adventure in his blood. His childhood fantasies were born as he sat in his piano teacher's waiting room every week poring over copies of *National Geographic* magazine. "As a land-locked Michigan kid with dreams of the ocean, I was always drawn to the articles about underwater exploration, especially shipwreck archeology," Greg recalls.

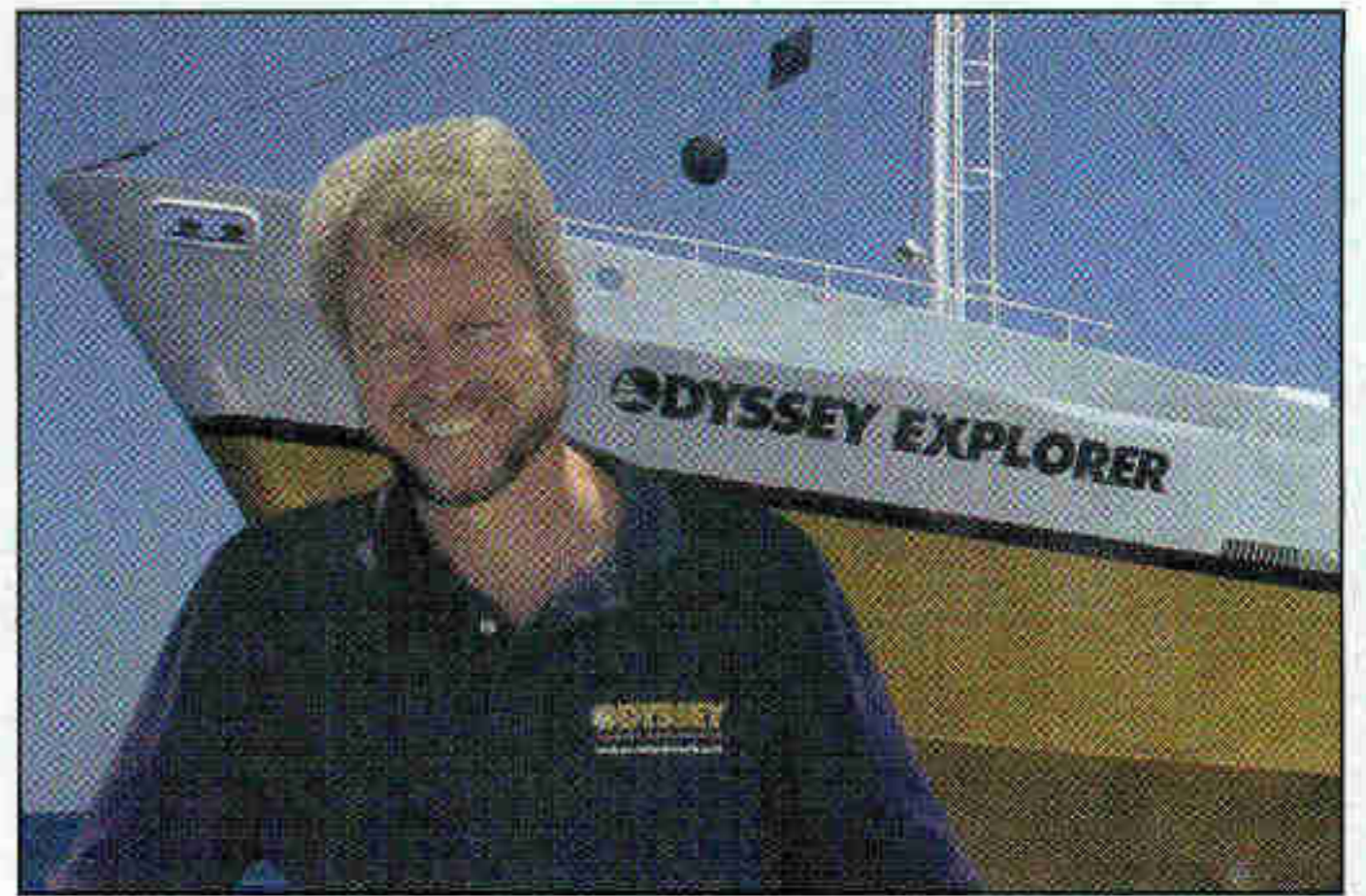
Today Greg's dreams have come true. As co-founder of Odyssey Marine Exploration, he leads a team of technicians and archaeologists who have made hundreds of deep ocean discoveries, ranging from Spanish galleons to Phoenician cargo ships to lost U-boats. Now Odyssey has found a fantastic piece of America's history – and they're going to share it.

A Fortune in Silver & Gold.

After years of searching, the Odyssey Marine Exploration team located the *SS Republic*, a Civil War-era paddle-wheel steamship. A hurricane took her to the bottom of the Atlantic off the Georgia coast in October, 1865. The *SS Republic* carried a fortune in gold & silver U.S. coins bound to rebuild New Orleans after the Civil War. Recovery of the *SS Republic* treasure made headlines worldwide and is the subject of a TV special.

The Mysterious "O". The shipwreck site was carefully mapped and photographed by Odyssey's archeologists. Each coin was delicately recovered by ZEUS, Odyssey's Remotely Operated

Odyssey Marine Exploration co-founder Greg Stemm in front of the Odyssey Explorer, the company's 251 foot deep-ocean archaeological platform.



Vehicle. As the coins came up from 1,700 feet beneath the Atlantic, Greg was stunned to see magnificent U.S. silver "Seated Liberty" half dollars dated from before the outbreak of the Civil War. But the biggest surprise was yet to come. Upon examining the half dollars, coin experts discovered that many of them bore an "O" mintmark – from the long-closed New Orleans Mint!



The detail of each 1860-O Half Dollar excavated from the *SS Republic* shipwreck is amazing.

The New Orleans Mint "O" mintmark

Shown actual size of 30.6 mm

Of all the *SS Republic* coins recovered, among the most important are those with the "O" mintmark. The Confederacy took over the New Orleans Mint in 1861, and made its own half dollars until they ran out of silver. To this day no one knows how these coins made their way from New Orleans to New York during the Civil War and then into the hold of the *SS Republic* for her final, fateful voyage in 1865. These silver coins are filled with history: made of silver from the famous Comstock Lode; minted at the old New Orleans Mint just as Lincoln became President; carried aboard a ship bound to rebuild a war-ravaged South; and then lost for 140 years, 1,700 feet beneath the Atlantic, until Odyssey's crew carefully recovered them from the sea!

Public demand for coins from the *SS Republic* has been frenzied. Individual coins have already sold at prices of \$1,000 to more than \$600,000 apiece.

A Special \$249 Offer. Greg is extending a special invitation to our readers. "This is a lifelong dream come true. Most people will never have the chance to go on such a quest. But, they can own a piece of history from this amazing find. These are coins with the historic New Orleans "O" mintmark struck the year Lincoln was elected. The detail is amazing – Miss Liberty's face, the folds in her garment, the individual feathers on the eagle! While they last, we're releasing a limited number of these authentic, 1860 "O" Mint silver half dollars from the *SS Republic* for the lowest price we have ever offered - just \$996. It is an incredible opportunity and to make it affordable for most anyone, we will deliver it after the first of four monthly installments of just \$249."

Each *SS Republic* 1860-O Silver Half Dollar is independently certified & encapsulated by the Numismatic Guaranty Corp (NGC) and displayed in a deluxe presentation case along with a Certificate of Authenticity, an illustrated history of the *SS Republic* and a DVD about the shipwreck and recovery. The quantity is restricted at this introductory price (plus S&H) so orders should be placed without delay to avoid disappointment (Many varieties of *SS Republic* coins have already sold out). Satisfaction is assured with a 30-Day Money-Back Guarantee (the coin and all included materials must be returned in their original condition to qualify).

To reserve your 1860 New Orleans Mint Silver Half Dollar from the *SS Republic* treasure, or for information about other silver and gold coins recovered from the *SS Republic*, call Odyssey Marine Exploration toll free at 1-800-456-2466 and request Special Offer SSD247-02 (Lines are open 24 hours a day, 7 days a week).

P.S. Greg will send an autographed first edition of the book "Lost Gold of the Republic" to the first 50 people to order.




Odyssey Marine Exploration's underwater robot, ZEUS, is lowered for another deep-sea exploration assignment.



Each coin comes displayed in a deluxe presentation case with a storybook and exciting DVD that documents the discovery of the *SS Republic*.

VOICES





Francis Collins finds a balanced ride between science and religion.

Francis Collins The Scientist as Believer

INTERVIEW BY JOHN HORGAN

*The often strained relationship between science and religion has become particularly combative lately. In one corner we have scientists such as Richard Dawkins and Steven Pinker who view religion as a relic of our superstitious, prescientific past that humanity should abandon. In the other corner are religious believers who charge that science is morally nihilistic and inadequate for understanding the wonders of existence. Into this breach steps Francis Collins, who offers himself as proof that science and religion can be reconciled. As leader of the Human Genome Project, Collins is among the world's most important scientists, the head of a multibillion-dollar research program aimed at understanding human nature and healing our innate disorders. And yet in his best-selling book, *The Language of God*, he recounts how he accepted Christ as his savior in 1978 and has been a devout Christian ever since. "The God of the Bible is also the God of the genome," he writes. "He can be worshiped in the cathedral or in the laboratory." Recently Collins discussed his faith with science writer John Horgan, who has explored the boundaries between science and spirituality in his own books *The End of Science* and *Rational Mysticism*. Horgan, who has described himself as "an agnostic increasingly disturbed by religion's influence on human affairs," directs the Center for Science Writings at the Stevens Institute of Technology in Hoboken, New Jersey.*

HORGAN: As a scientist who looks for natural explanations of things and demands evidence, how can you also believe in miracles, like the resurrection?

COLLINS: I don't have a problem with the concept that miracles might occasionally occur at moments of great significance, where there is a message being transmitted to us by God Almighty. But as a scientist I set my standards for miracles very high.

HORGAN: The problem I have with miracles is not just that they violate what science tells us about how the world works. They also make God seem too capricious. For example, many people believe that if they pray hard enough God will intercede to heal them or a loved one. But does that mean that all those who don't get better aren't worthy?

We may understand a lot about biology and how to prevent illness. But I don't think we'll ever figure out how to stop humans from doing bad things to each other.

COLLINS: In my own experience as a physician, I have not seen a miraculous healing, and I don't expect to see one. Also, prayer for me is not a way to manipulate God into doing what we want him to do. Prayer for me is much more a sense of trying to get into fellowship with God. I'm trying to figure out what I should be doing rather than telling Almighty God what he should be doing. Look at the Lord's Prayer. It says, "Thy will be done." It wasn't, "Our Father who art in Heaven, please get me a parking space."

HORGAN: I must admit that I've become more concerned lately about the harmful effects of religion because of religious terrorism like 9/11 and the growing power of the religious right in the United States.

COLLINS: What faith has not been used by demagogues as a club over somebody's head? Whether it was the Inquisition or the Crusades on the one hand or the World Trade Center on the other? But we shouldn't judge the pure truths of faith by the way they are applied any more than we should judge the pure truth of love by an abusive marriage. We as children of God have been given by God this knowledge of right and wrong, this Moral Law, which I see as a particularly compelling signpost to his existence. But we also have this thing called free will, which we exercise all the time to break that law. We shouldn't blame faith for the ways people distort it and misuse it.

HORGAN: Many people have a hard time believing in God because of the problem of evil. If God loves us, why is life filled with so much suffering?

COLLINS: That is the most fundamental question that all seekers have to wrestle with. First of all, if our ultimate goal is to grow, learn, and discover things about ourselves and things about God, then unfortunately a life of ease is probably not the way to get there. I know I have learned very little about myself or God when everything is going well. Also, a lot of the pain and suffering in the world we cannot lay at God's feet. God gave us free will, and we may choose to exercise it in ways that end up hurting other people.

HORGAN: Physicist Steven Weinberg, who is an atheist, asks why six million Jews, including his relatives, had to die in the Holocaust so that the Nazis could exercise their free will.

COLLINS: If God had to intervene miraculously every time one of us chose to do something evil, it would be a very strange, chaotic, unpredictable world. Free will leads to people doing terrible things to each other. Innocent people die as a result. You can't blame anyone except the evildoers for that. So that's not God's fault. The harder question is when suffering seems to have come about through no human ill action. A child with cancer, a natural disaster,

world beat

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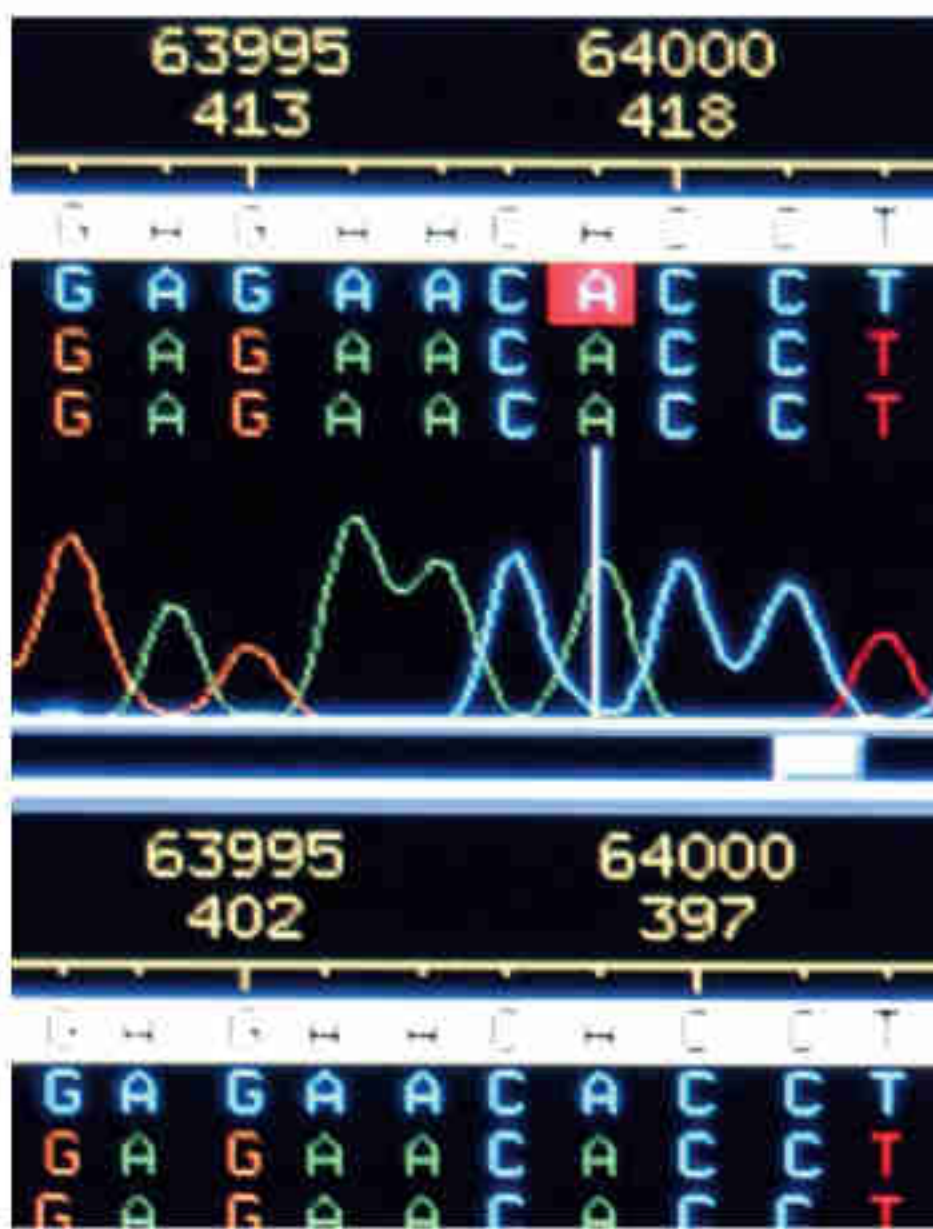
Like here, according to the Flat Earth Society. They believe this to be one of the four corners of the Earth—that if you venture too far beyond it, you would actually fall off. Fact? Fiction? It hardly makes a difference. It's that the awesome beauty of this place compelled such a hypothesis. One thing is for certain—no one who sees the edge looks at the world the same way again. Call Catelyn at 1-800-563-6353 or visit newfoundlandlabrador.com.


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An automated DNA sequencing machine depicts a tiny fragment of the genetic code of life. Collins led the government effort to decode the entire human genome.

a tornado or tsunami. Why would God not prevent those things from happening?

HORGAN: Some philosophers, such as Charles Hartshorne, have suggested that maybe God isn't fully in control of his creation. The poet Annie Dillard expresses this idea in her phrase "God the semi-competent."

COLLINS: That's delightful—and probably blasphemous! An alternative is the notion of God being outside of nature and time and having a perspective of our blink-of-an-eye existence that goes both far back and far forward. In some admittedly metaphysical way, that allows me to say that the meaning of suffering may not always be apparent to me. There can be reasons for terrible things happening that I cannot know.

HORGAN: I'm an agnostic, and I was bothered when in your book you called agnosticism a "cop-out." Agnosticism doesn't mean you're lazy or don't care. It means you aren't satisfied with any answers for what after all are ultimate mysteries.

COLLINS: That was a put-down that should not apply to earnest agnostics who have considered the evidence and still don't find an answer. I was reacting to the agnosticism I see in the scientific community, which has not been arrived at by a careful examination of the evidence. I went through a phase when I was a casual agnostic, and I am perhaps too quick to assume that others have no more depth than I did.

HORGAN: Free will is a very important concept to me, as it is to you. It's the basis for our morality and search for meaning. Don't you worry that science in general and genetics in particular—and your work as head of the Genome Project—are undermining belief in free will?

COLLINS: You're talking about genetic determinism, which implies that we are helpless marionettes being controlled by strings made of double helices. That is so far away from what we know scientifically! Heredity does have an influence not only over medical risks but also over certain behaviors and personality traits. But look at identical twins, who have exactly the same DNA but often don't behave alike or think alike. They show the importance of learning and experience—and free will. I think we all, whether we are religious or not, recognize that free will is a reality. There are some fringe elements that say, "No, it's all an illusion, we're just pawns in some computer model." But I don't think that carries you very far.

HORGAN: What do you think of Darwinian explanations of altruism, or what you call agape, totally selfless love and compassion for someone not directly related to you?

I don't have a problem with the concept that miracles might occasionally occur. But as a scientist I set my standards for miracles very high.

COLLINS: It's been a little of a just-so story so far. Many would argue that altruism has been supported by evolution because it helps the group survive. But some people sacrificially give of themselves to those who are outside their group and with whom they have absolutely nothing in common. Such as Mother Teresa, Oskar Schindler, many others. That is the nobility of humankind in its purist form. That doesn't seem like it can be explained by a Darwinian model, but I'm not hanging my faith on this.

HORGAN: What do you think about the field of neurotheology, which attempts to identify the neural basis of religious experiences?

COLLINS: I think it's fascinating but not particularly surprising. We humans are flesh and blood. So it wouldn't trouble me—if I were to have some mystical experience myself—to discover that my temporal lobe was lit up. That doesn't mean that this doesn't have genuine spiritual significance. Those who come at this issue with the presumption that there is nothing outside the natural world will look at this data and say, “Ya see?” Whereas those who come with the presumption that we are spiritual creatures will go, “Cool! There is a natural correlate to this mystical experience! How about that!”

HORGAN: Some scientists have predicted that genetic engineering may give us superhuman intelligence and greatly extended life spans, perhaps even immortality. These are possible long-term consequences of the Human Genome Project and other lines of research. If these things happen, what do you think would be the consequences for religious traditions?

COLLINS: That outcome would trouble me. But we're so far away from that reality that it's hard to spend a lot of time worrying about it, when you consider all the truly benevolent things we could do in the near term.

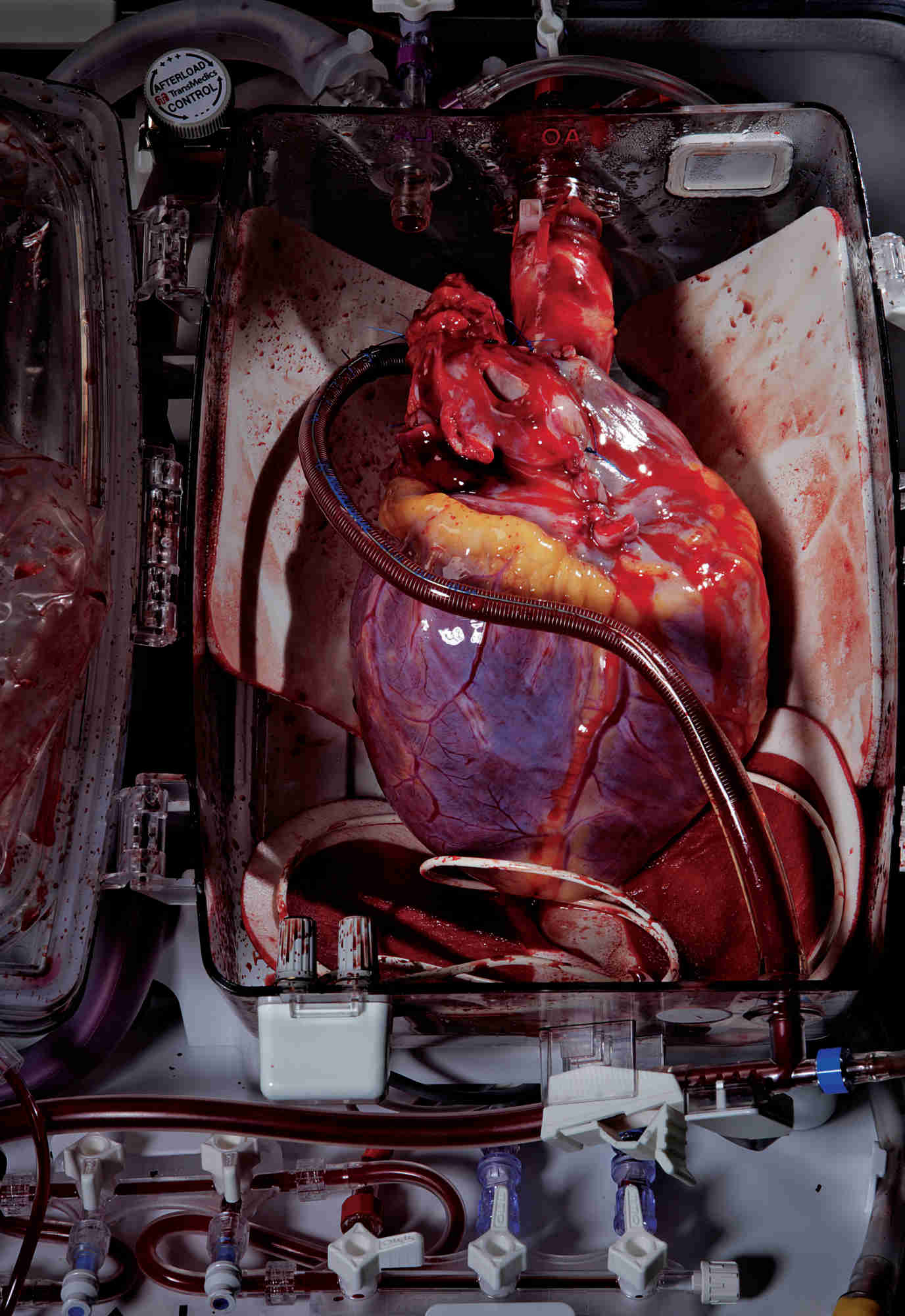
HORGAN: I'm really asking, does religion require suffering? Could we reduce suffering to the point where we just won't need religion?

COLLINS: In spite of the fact that we have achieved all these wonderful medical advances and made it possible to live longer and eradicate diseases, we will probably still figure out ways to argue with each other and sometimes to kill each other, out of our self-righteousness and our determination that we have to be on top. So the death rate will continue to be one per person, whatever the means. We may understand a lot about biology, we may understand a lot about how to prevent illness, and we may understand the life span. But I don't think we'll ever figure out how to stop humans from doing bad things to each other. That will always be our greatest and most distressing experience here on this planet, and that will make us long the most for something more. □

Mending Broken Hearts

Cheeseburgers, smoking, stress, the rise of the couch potato: These are the usual suspects on the list of risk factors for heart disease, a malady reaching global epidemic proportions. Now discoveries about genetic triggers may help us spot trouble before it starts.

A human heart destined for transplant lies cradled in a device that can keep it warm and beating—and viable for many hours longer than the conventional method for handling donor hearts: immersion in a saline solution and packing in ice.



AFTERLOAD
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Daniel Allen lived 54 days with an artificial heart implanted in his chest. He was comforted by the thump, says Sharon, his wife, who could hear the heart beating from across the room. A couple of weeks after this photo was made Allen received a transplanted human heart, but he died from an infection within months.





Getting a good look at the condition of a live human heart was once impossible without invasive surgery. The organ at left is, in fact, a museum specimen. But dramatic advances in computed tomography now provide detailed scans in ten scalpel-free seconds. This image of a heart beating in a human chest reveals a narrowed artery—potential trouble.



More than 60,000 miles of arteries, veins, and capillaries in an adult body pulsate to a muscular rhythm—100,000 heartbeats a day. Scientists once viewed the cardiovascular system as a pump and a lot of pipes; now they increasingly focus on the molecular level.

LADY OF ACHILLE
AND BOWY
1885
J. P. H. H. H. H.

BY JENNIFER KAHN

PHOTOGRAPHS BY ROBERT CLARK

Gloria Stevens is lying on her back, sedated but alert, staring at an image of her own beating heart. Metaphorically, Gloria's heart is the very core of her emotional self—not to be worn on the sleeve, much less displayed on an overhead monitor. More literally, it is a blood-filled pump about the size of a clenched fist whose rhythmic contractions have kept Gloria alive for 62 years, and with a little tinkering will keep her going for an indeterminate number more.

At this moment, her doctor is threading a thin catheter up through her femoral artery from an incision in her groin, on into the aorta, and from there into one of the arteries encircling Gloria's heart. At the tip of the catheter is a small balloon. The doctor gently navigates the tip to a spot where plaque has narrowed the artery's channel by 90 percent. With a quick, practiced movement he inflates the balloon to push back the artery wall, deflates the balloon, then inserts an expandable stent—it looks like a tiny tube of chicken wire—that will keep the passage open. As Gloria watches on the monitor, the crimp in her artery disappears, and a wide laminar flow gushes through the vessel, like a river in flood.

The procedure is over. It has lasted only half an hour. In all likelihood, Gloria will be able to go home the next day. So will a few thousand other patients in the United States undergoing such routine angioplasty—more than a million of them a year. Pipe fixed, patient cured, right?

Wrong.

Because of her treatment, Gloria's quality of life will likely improve. She'll breathe easier and maybe live longer. But she is hardly cured. Her coronary atherosclerosis—a hardening and narrowing of the arteries that supply the heart with oxygen-rich blood—still leaves her vulnerable to future blockages and coronary heart disease.

Although hearts suffer many maladies—valves leak, membranes become inflamed—coronary heart disease, which can lead to heart attack and ultimately to heart failure, is the number one killer of both men and women in the United States, where 500,000 die annually. Worldwide, it kills 7.2 million people every year. Exacerbated by the export of Western lifestyle—motorized transport, abundant meat and cheese, workdays conducted from the comfort of a well-padded chair—incidence of the disease is soaring.

To help stem this lethal tide, cardiologists can prescribe such cholesterol-lowering drugs as statins to help keep arteries clear. They can advise patients to change their habits, or they can operate to fix an immediate problem. Angioplasty is one procedure, and surgery to

bypass the diseased arteries is another—each year more than 400,000 bypasses are performed in the U.S. Transplants can replace severely damaged hearts, and artificial ones can keep people alive while they wait for a donor heart. But in the face of an impending global epidemic, none of these stopgap measures addresses the essential question: Who gets heart attacks and why?

The human heart beats 100,000 times a day, propelling six quarts of blood through 60,000 miles of vessels—20 times the distance across the U.S. from coast to coast. The blood flows briskly, surging out of a ten-ounce heart so forcefully that large arteries, when severed, can send a jet of blood several feet into the air. Normally the relentless current helps keep blood vessels clean. But where an artery bends, tiny eddies form, as in a bend in a river. This is where bits of sticky, waxy cholesterol and fat can seep into the artery wall and oxidize, like butter going rancid. Other matter piles up too. Eventually, the whole mass calcifies into a kind of arterial stucco, or plaque (diagram, page 54).

Until recently, cardiologists approached heart disease as a plumbing problem. Just as mineral deposits restrict the flow of water through a pipe, an accretion of plaque impedes the flow of blood through an arterial channel. The more crud in the system, the greater likelihood that a dammed artery will trigger a heart attack. Doctors now dismiss this “clogged-pipes model” as an idea whose time has passed. It’s just not that simple.

Most heart attacks are caused by plaque embedded within the artery wall that ruptures, cracking the wall and triggering the formation of a blood clot. The clot blocks the flow of blood to the heart muscle, which can die from lack of oxygen and nutrients. Suddenly, the pump stops pumping.

Contrary to the clogged pipes model, heart attacks generally occur in arteries that have minimal or moderate blockage, and their occurrence depends more on the *kind* of plaque than on the quantity. Scientists have been struggling to figure out what type is most responsible. Paradoxically, findings suggest that immature, softer plaques rich in cholesterol are more unstable and likely to rupture than the hard, calcified, dense plaques that extensively narrow the artery channel. But understanding the root cause of the disease will require much more research. For one thing, human hearts, unlike plumbing

fixtures, are not stamped from a mold. Like the rest of our body parts, they are products of our genes.

DON STEFFENSEN was putting duck-hunting decoys out on a small lake one fall afternoon in southwestern Iowa when his heart attack hit. The infarction was massive and unexpected. It’s likely that Steffensen survived only because a buddy was carrying nitroglycerin tablets and quickly slipped one under his friend’s tongue. Nitroglycerin is used to make dynamite; in the body, a heavily diluted form releases nitric oxide, which signals the smooth muscle cells in veins and arteries to relax, dilating the vessels.

The Steffensen clan is enormous: more than 200 relatives spread over three generations, many of the youngest are now dispersed from Iowa to New York and beyond. Although heart trouble is common in the family, it had never struck anyone as unusual. “I attributed it to diet,” shrugs Tina, a slim 38-year-old and the family’s only vegetarian.

It was a reasonable conclusion. The Steffensens were raised on the kind of farm food that the state is famous for—ham balls, meatloaf, pie, macaroni and cheese—and still popular even as careers have moved indoors. Driving north through cornfields to meet some of the family in Buffalo Center, I dined at a restaurant offering deep-fried sandwiches. A single ham and cheese hoagie—dunked in hot fat and served sizzling—seemed capable of stopping a heart all on its own.

But could the high incidence of heart trouble among the Steffensens be related to something else besides high-fat diets? Eleven years after Don’s attack, his wife, Barbara, happened to overhear a doctor describing a study about the genetics of heart attacks.

Curious, Don and 20 of his relatives each sent a vial of blood to the Cleveland Clinic, where the research was being conducted. Eric Topol, a cardiologist and genetics researcher at the clinic, spent a year studying their DNA. Each person’s genome comes with millions of individual variations, but Topol was looking for something distinctive—and shared only by the members of the clan with heart trouble. The mutation he and his team finally spotted, in a gene called *MEF2A*, produced a faulty protein. “We knew

we had something,” Topol says. “But the question was: How does this sick protein, present at birth, lead to heart attacks 50 years later in life?”

Topol himself is as lean as a greyhound and weathered in a cowboyish way. He talks slowly and eats minimally: salads for dinner and high-fiber cereal for breakfast. He doesn’t eat lunch at all. Like almost every cardiologist I’ve talked to, he takes statins preventively, and his cholesterol count is a low 135. His children, 22 and 25, also eat uncommonly well for their ages. “People have looked at the cadavers of men in their 20s who died in car accidents or as casualties of war, and nearly all had arterial cholesterol deposits,” Topol said as we walked to his lab. “This disease starts much earlier than people realize.”

Using endothelial cells (which line the inside of the artery wall) grown in culture, Topol set about figuring out what the *MEF2A* mutation does. He and his coworkers created some cells carrying the Steffensen variant, and others with the normal form of the protein. Both cell proteins were tagged fluorescent green so their locations could be visualized on a computer screen. The resulting images revealed a striking difference.

In a normal cell, all the *MEF2A* protein was inside the nucleus; on the screen, the cell resembled a fried egg with a fluorescent green yolk. But in the cells carrying the mutated version, the nucleus did not glow; instead the cell membrane was edged by a thin, luminous green line: a layer of *MEF2A* protein, trapped where it cannot serve its usual purpose. Topol believes that this defect affects the integrity of the coronary artery walls, rendering them more vulnerable to cracking when the plaque embedded in them ruptures. And each crack brings an increased chance of a heart attack.

Since this discovery, the Steffensens have become famous, appearing on shows like *60 Minutes II*. Their mutant gene turns up in a Robin Cook novel titled *Marker*, about a health insurance company in New York that secretly screens patients for the *MEF2A* mutation and then kills them to preempt future medical-care payouts. Lively reading, but the Steffensen gene is an unlikely target for an insurance company, in part because it is an uncommon genetic defect.

Topol’s study did find that although

dysfunctional *MEF2A* is very rare, the chance of heart disease in those carrying it may approach 100 percent. Most other genetic variations identified thus far increase the risk by much less. As it turns out, Topol himself carries a bum gene: *apoE4*, which affects inflammation in the arteries. Unlike *MEF2A*, it is common; every fourth person has it.

“Heart disease is not a one- or two-gene problem,” says Steven Ellis, a Cleveland Clinic cardiologist who oversees a 10,000-person genetic study known as GeneBank that collects DNA samples from patients who enter hospitals with atherosclerosis. Ellis, like most cardiac researchers, suspects that dozens of genes end up contributing to a predisposition: Some affect arterial integrity, others inflammation

**CARDIOLOGISTS CAN
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OPERATE TO FIX AN IMMEDIATE
PROBLEM. BUT IN THE FACE
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STOPGAP MEASURES
ADDRESS THE ESSENTIAL
QUESTION: WHO GETS HEART
ATTACKS AND WHY?**

(which both causes and exacerbates arterial cracks), and still others the processing of lipids (the fats and cholesterol that turn into plaques). Of the several dozen genes, each may contribute just one percent to a person’s total risk—an amount that may be compounded, or offset, by outside factors like diet. As one doctor told me, any person’s heart attack risk is “50 percent genetic and 50 percent cheeseburger.”

The point of tracking down all these small mutations, Ellis explains, is to create a comprehensive blood test—one that could calculate a person’s genetic susceptibility by adding up the number of risky (and, eventually, beneficial) variables. Combined with other important factors, such as smoking, weight, blood pressure, and cholesterol levels, doctors could decide which patients need (Continued on page 55)

THE STEFFENSEN FAMILY

Don Steffensen holds a 60-year-old portrait of his mother, father, and siblings (Don is number 4). He and most of his siblings tested positive (below) for a mutation in the *MEF2A* gene, which may be linked to heart disease. In fact, all have had various heart problems. But doctors agree that genes alone can't forecast the future. Diet and exercise are still crucial.

- 1 Clyde: not tested
- 2 Cecil: tested positive
- 3 DeVere: tested positive
- 4 Don: tested positive
- 5 Garth: not tested
- 6 JoAnn: tested positive
- 7 Jeanette: tested positive
- 8 Mae: not tested
- 9 Marvin: tested positive
- 10 Elayne: tested positive
- 11 Zilpha: not tested
- 12 Arthur: not tested
- 13 Betty: tested negative





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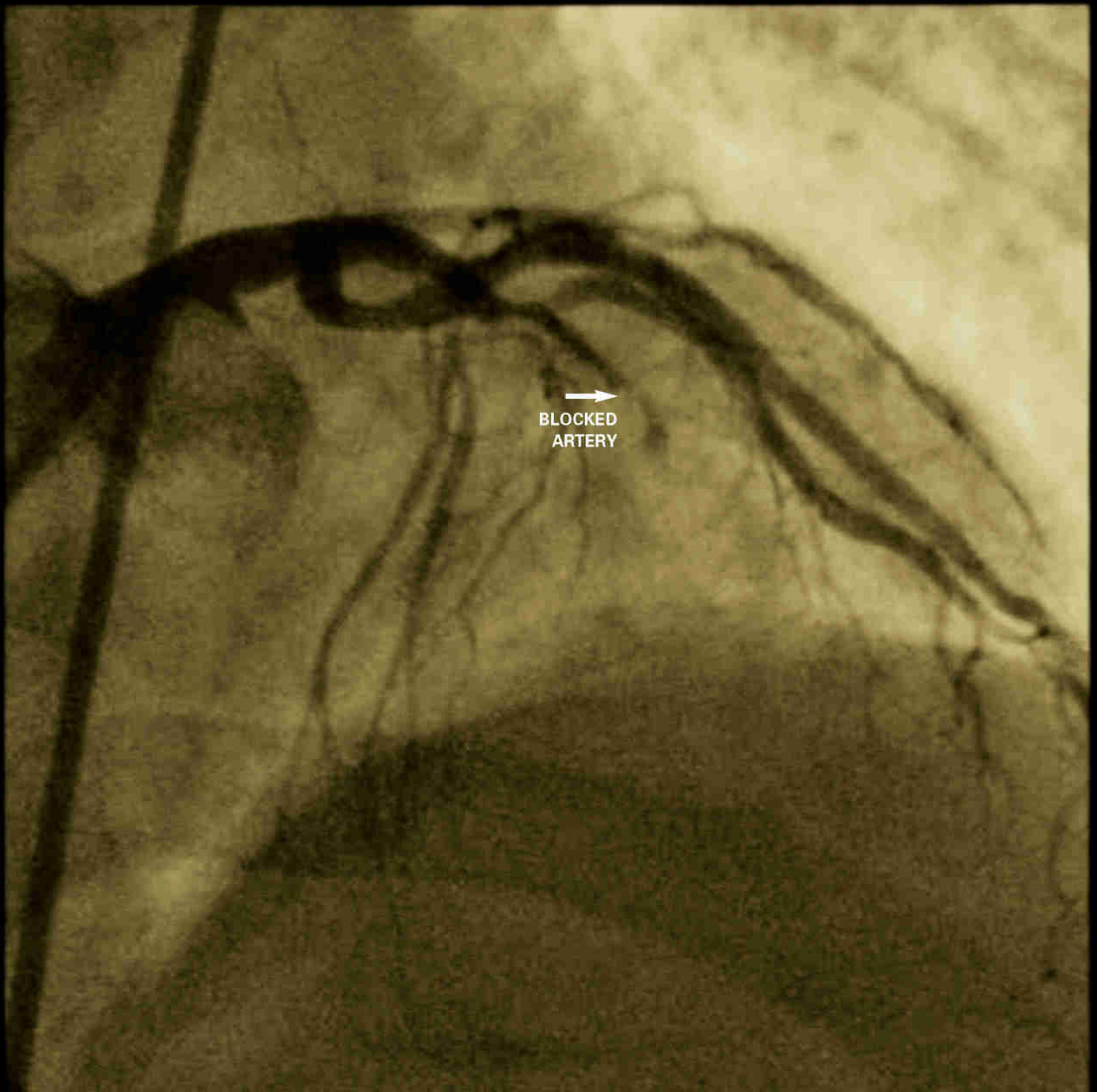
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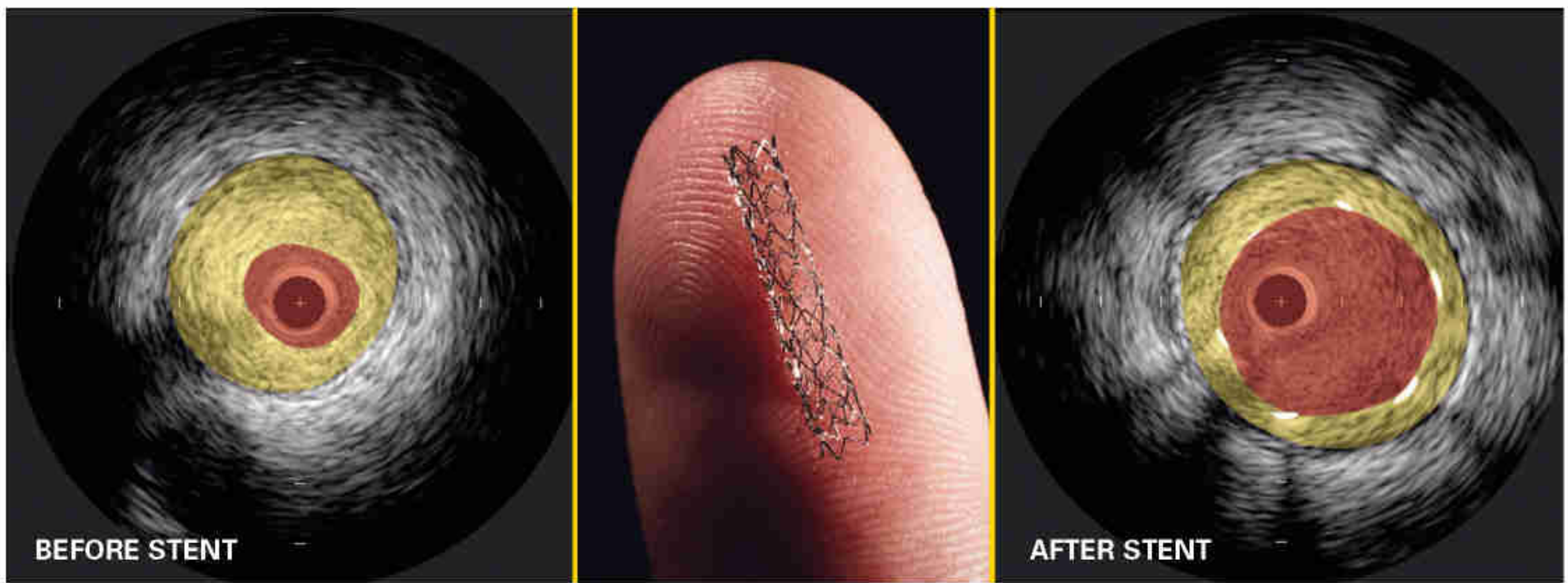
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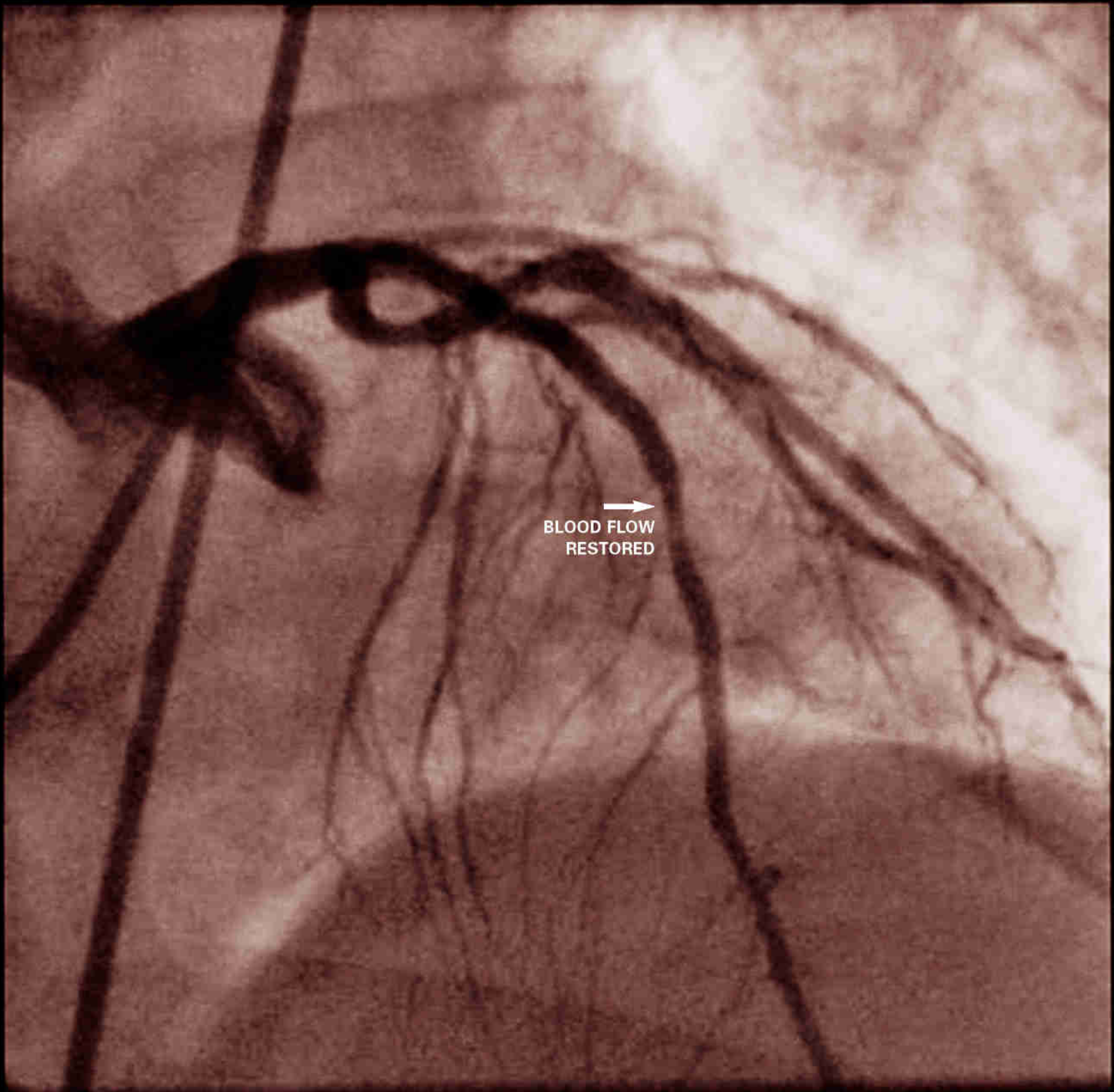
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PICTURING HEART DISEASE An angiogram reveals an abrupt closure—referred to as a “widow maker”—in a critical coronary artery (below left). This technique uses a catheter, dye, and x-rays to navigate and study blood vessels. In a second angiogram, after a stent like the one shown opposite has been inserted, blood flow is restored (below right). With a different technique, intravascular ultrasound, doctors are able to examine the inside of a vessel in cross section (opposite, left and right). Plaque (yellow) constricts blood flow (red). Once a stent has been inserted and the wall propped open, blood flows more freely. Says Dr. Paul Yock of Stanford University: “Ultrasound helps us completely expand the stents so they have a better chance of staying open.”





YASUHIRO HONDA AND PAUL YOCC, STANFORD UNIVERSITY SCHOOL OF MEDICINE (ABOVE LEFT AND RIGHT);
ALAN HERMAN AND NORTH MEMORIAL MEDICAL CENTER, MINNEAPOLIS (BELOW LEFT AND RIGHT)



DANGEROUS RUPTURES

Cholesterol in the blood can enter arterial walls, causing plaque to form. Tiny pockets of plaque accumulate in a process called atherosclerosis. Plaque can build up for decades and suddenly rupture into the bloodstream with deadly consequences.

THE PROCESS

- 1 Cholesterol in the bloodstream infiltrates the arterial wall.
- 2 Immune system dispatches macrophages to consume cholesterol. The bloated macrophages become foam cells.
- 3 Foam cells accumulate and become a major component of plaque.
- 4 To keep the arterial wall slick, smooth muscle cells form a cap.
- 5 Foam cells in the plaque secrete chemicals that weaken the cap.

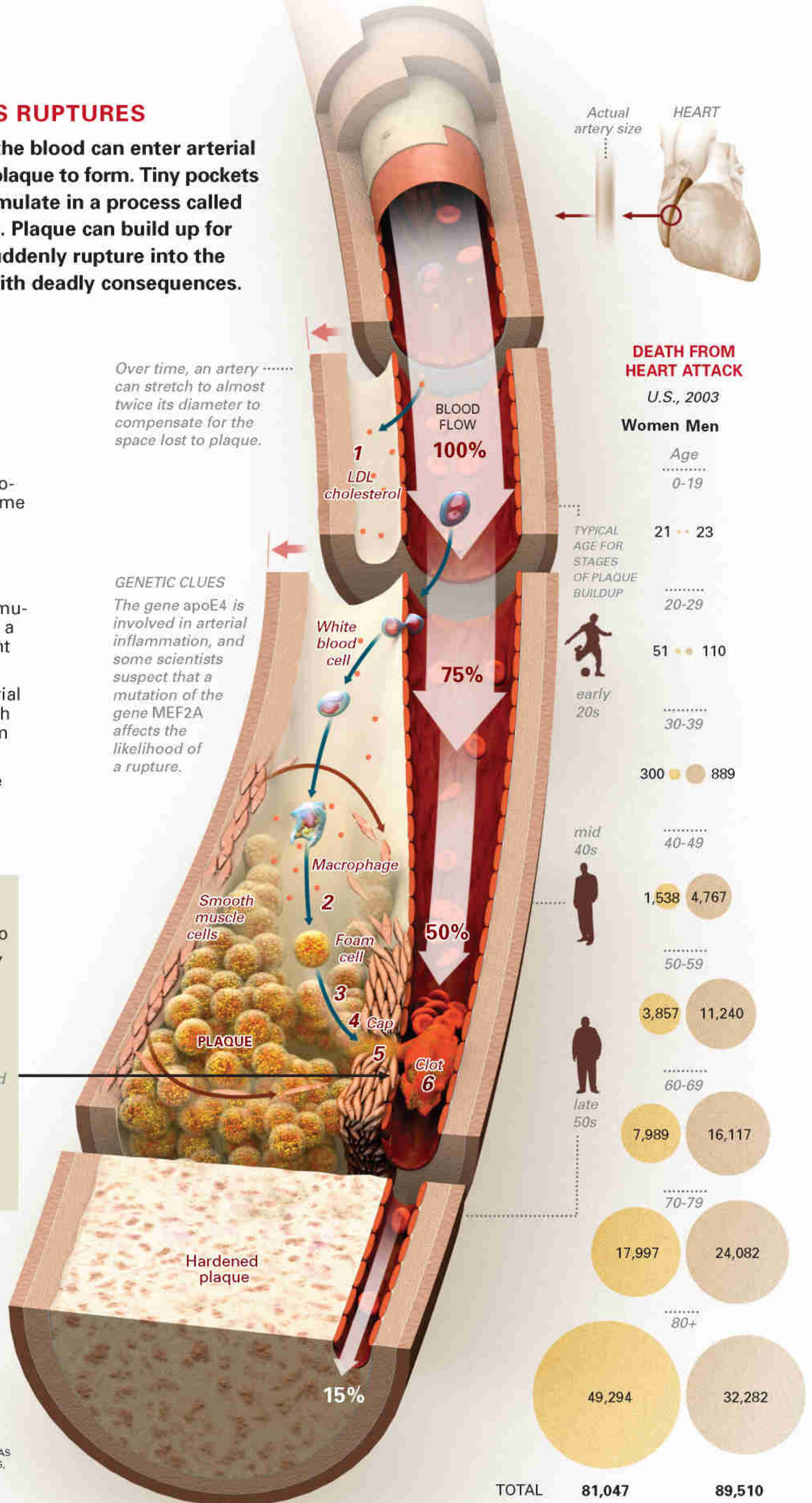
- 6 **Heart attack**
If the cap cracks, plaque seeps into the bloodstream, and a clot forms that can block blood flow.

Most heart attacks are triggered in arteries where blood flow is less than 50 percent blocked and where plaques and caps are soft and more likely to rupture.

Over time, an artery can stretch to almost twice its diameter to compensate for the space lost to plaque.

GENETIC CLUES

The gene apoE4 is involved in arterial inflammation, and some scientists suspect that a mutation of the gene MEF2A affects the likelihood of a rupture.



SOURCES: RICHARD A. LANGE, JOHNS HOPKINS HOSPITAL; PETER LIBBY, BRIGHAM AND WOMEN'S HOSPITAL; ERIC J. TOPOL, SCRIPPS CLINIC; THOMAS THOM, NATIONAL HEART, LUNG, AND BLOOD INSTITUTE
ART BY BRYAN CHRISTIE

REDUCING RISKS IN THE U.S.

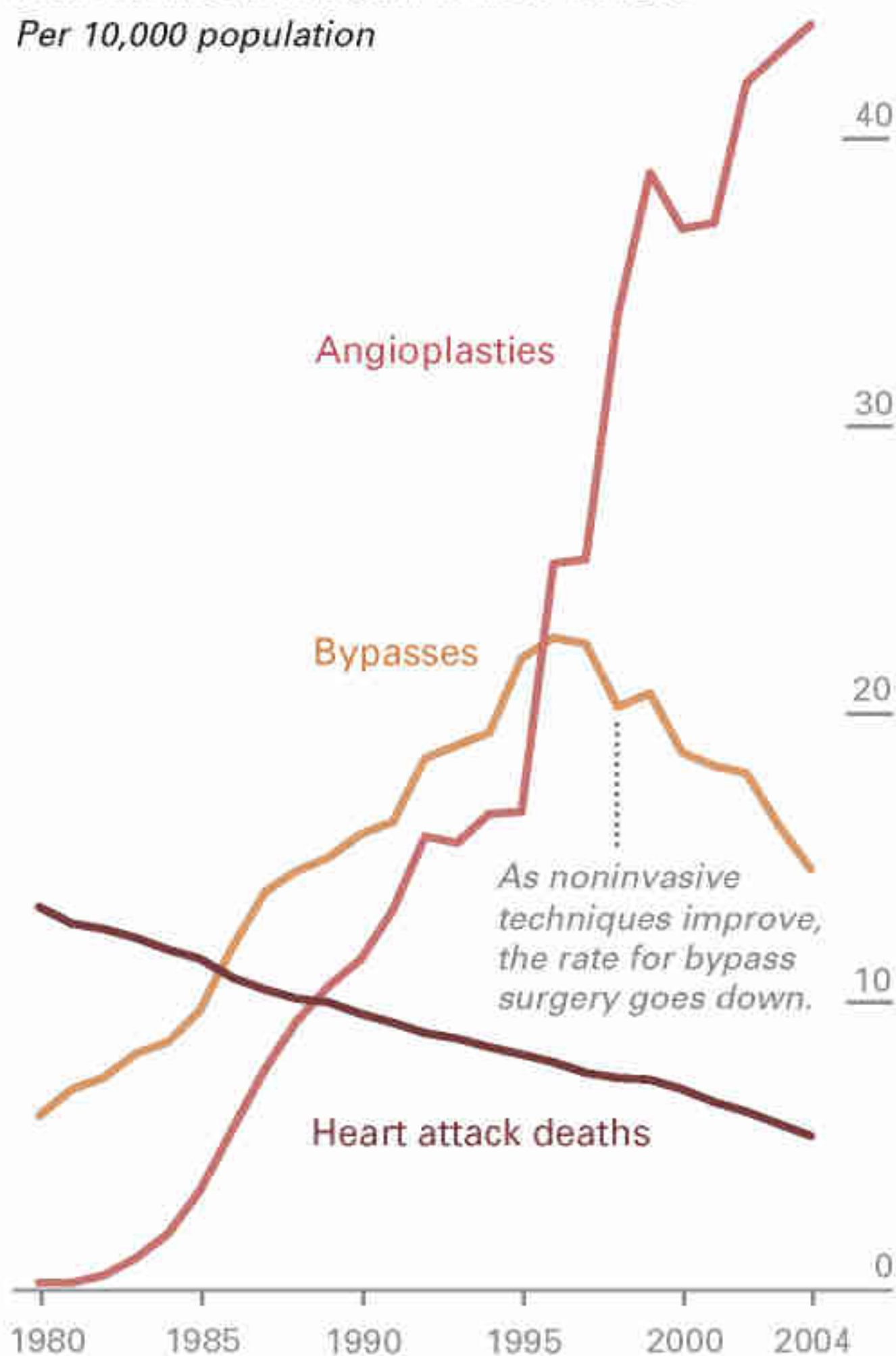
Fifty years ago, risk factors for heart disease often led to premature death. But in recent decades drugs such as statins—and procedures such as angioplasty and bypass surgery—can keep chronic heart disease manageable.

HEART ATTACK RISK FACTORS

- **Unhealthy combination of “good” and “bad” cholesterol** quadruples the risk.
- **Diabetes** quadruples the risk for women and doubles it for men.
- **Hypertension** nearly triples the risk for men and doubles it for women.
- **Stress and depression** almost triple the risk.
- **Healthy diet** decreases the risk by close to 30 percent.
- **Abdominal obesity** more than doubles the risk.
- **Lack of exercise** increases the risk by about 20 percent.
- **Smoking** can double, even triple, the risk.

Procedures and heart attack deaths

Per 10,000 population



SOURCES: THOMAS THOM, NATIONAL HEART, LUNG, AND BLOOD INSTITUTE; GAUTAM GOWRISANKARAN, WASHINGTON UNIVERSITY IN ST. LOUIS; SALIM YUSUF, McMASTER UNIVERSITY, THE INTERHEART STUDY

(Continued from page 49) aggressive treatment, such as high-dose statins, and which ones are likely to benefit from exercise or other lifestyle changes. Some genes already can predict whose cholesterol level will respond strongly to dietary changes and whose won't. Assessing risk is crucial, Ellis says, because heart disease is often invisible. In fact, 50 percent of men and 64 percent of women who die of heart disease die suddenly, without experiencing any previous symptoms.

Although standard tests can detect atherosclerosis, they aren't foolproof. They may reveal plaques, but give no indication whether or not they are life-threatening. Tests like angiography, for example, where doctors inject a dye into the bloodstream and track it with x-rays (pages 52-3), can show how much blood is flowing through an artery, but not discern the plaques embedded inside the artery wall—often the culprit in a heart attack.

Researchers have been working to solve this problem with scanners that provide pictures of the arterial wall itself, but it's a tricky task. Normal cardiac artery walls are about a millimeter thick. Coronary arteries move with every beat of the heart, 70 times a minute. It's tough to get a clear image of something so small in constant motion.

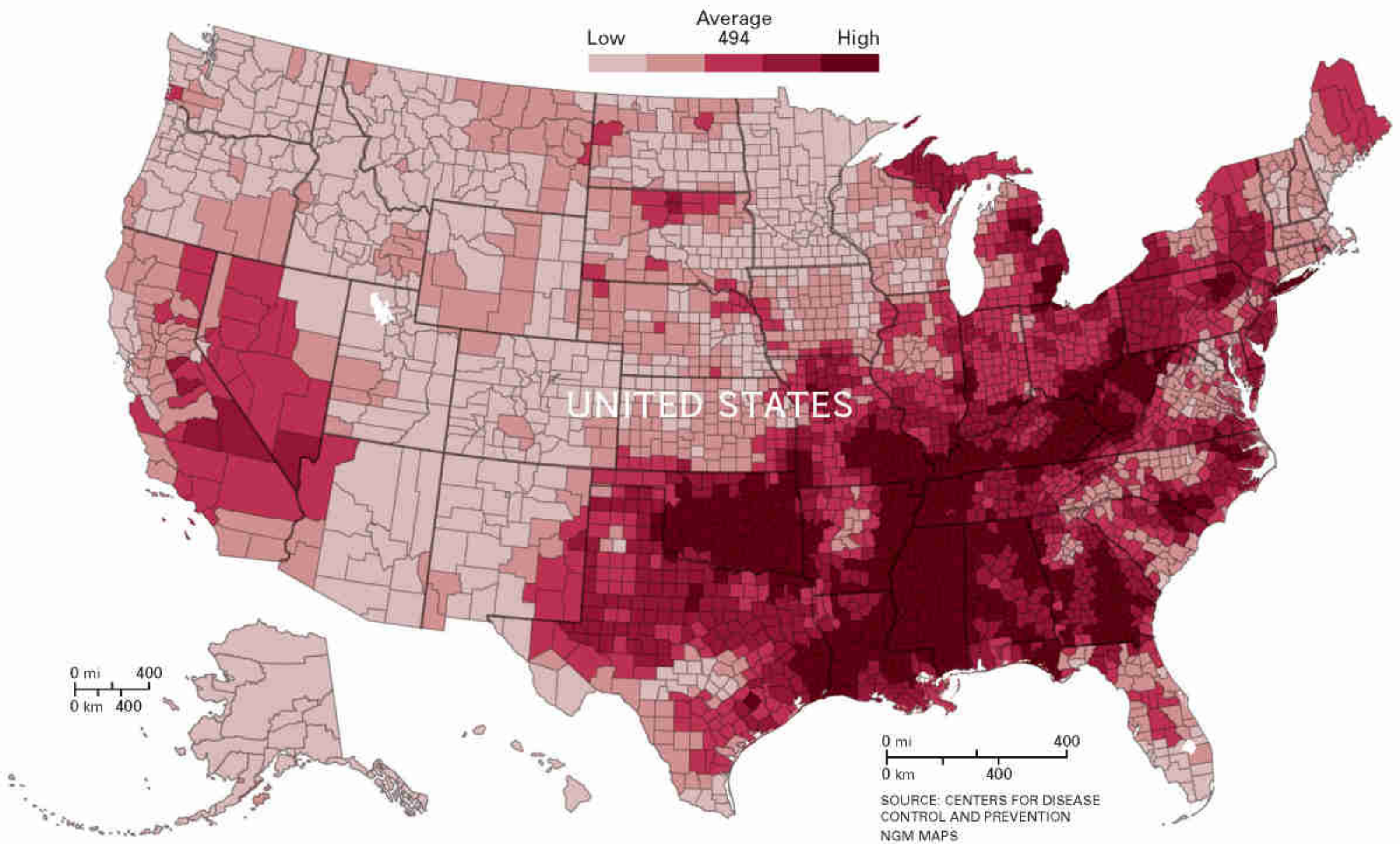
Difficult, but not impossible. As I walk through the basement of the Cleveland Clinic, I pass a room containing a large, blue, plastic doughnut as tall as I am, with a woman's legs sticking out of the middle. The doughnut is a computed tomography (CT) scanner, a kind of three-dimensional x-ray machine that's also used for imaging tumors. The scanner, aided by medications that reduce a patient's heart rate and an injectable dye that highlights the arteries, can produce startlingly clear pictures.

Scrolling through images on his computer monitor, Mario Garcia, the clinic's director of cardiac imaging, retrieves one that looks like a black-and-white landscape photographed from a plane, with a single, large river running through it. As Garcia zooms in on the river, a series of white lumps appears on the bank—hard plaques bright with calcium. But there is also a tiny black smudge. “That's the type we believe causes a heart attack,” he says with satisfaction, pointing to the smudge of soft plaque. “It's a rare opportunity to see that.”

As compelling as the CT scan is, it's still

HEART DISEASE DEATH RATES, 1999-2003

Average annual deaths per 100,000 adults 35 years and older, by county



Why are death rates from heart disease so low in Minnesota and so high in the deep South? According to the Centers for Disease Control and Prevention, factors could include the availability—or absence—of quality health care, emergency medical services, and affordable heart-healthy foods. Research has shown that race and ethnicity can also affect risk.

an imperfect tool for predicting heart disease. It's expensive, for one, and the dose of radiation from the x-rays makes it ill suited for use in healthy-patient annual exams. And although it sees arterial plaques, even soft plaques inside arterial walls, it can't reveal whether those plaques are likely to crack and cause a heart attack.

Until there are tests, genetic or otherwise, that give a clearer measure of risk, everyone would be advised to exercise, watch their diet, and take statins for elevated cholesterol—the same advice doctors gave when the clogged-pipes model of heart disease reigned unchallenged.

AT THE CLEVELAND CLINIC, cardiologist Stephen Nissen has conducted several studies on statins such as Lipitor, which reduce the amount of LDL (“bad” low-density lipoprotein) cholesterol made by the liver. Nissen is an advocate of lowering cholesterol by any means necessary. Does he take a statin? “You bet!” he says. “I have no

intention of dying of the disease I treat.” His LDL level is a paltry 51. Of eight cardiologists I spoke with, all but one were taking the medication. (Some studies now seem to show that lowering even normal cholesterol levels has a protective effect.) HDL (“good” high-density lipoprotein) cholesterol is another story. Nissen calls it the “arterial-wall garbage barge” because of its ability to remove cholesterol from clogged arteries. Not all HDL can do this; some is dysfunctional. But tests have shown that raising the HDL level in genetically engineered lab mice can shrink their arterial plaques.

A drug that could raise functional HDL levels in humans would likely become the next multibillion-dollar blockbuster, and a few are in various stages of testing. However, the trial of a Pfizer drug called torcetrapib ended in failure. Torcetrapib had been shown, in combination with Lipitor, to raise HDL levels 44 to 66 percent with a once-a-day pill. But the increase was



When the Jackson Heart Study Choir sings gospel tunes, they witness to an observation made by the study, based in Jackson, Mississippi: Spiritual activity is associated with lower blood pressure (high blood pressure is a risk factor for heart disease). The study examines why the rate of cardiovascular disease is so high among African Americans.

not necessarily in functional HDL, and the drug was also associated with elevated blood pressure. In December, when data showed a 60 percent higher death rate in patients taking torcetrapib with Lipitor than in those taking Lipitor alone, Pfizer abruptly ended the trial.

It's not clear whether the problem lay with one drug or an entire class of drugs. Until further research is completed, the several different statins on the market will remain the most prescribed class of drugs in the world, with 11.6 million prescriptions filled monthly in the U.S. alone. Pfizer's Lipitor may be the best-selling drug ever made, with 12 billion dollars in annual worldwide sales.

But statins, like any drug, carry the risk of side effects: Muscle aches are a well-known effect, and periodic blood tests to check liver function are recommended. The fact is, many of us just like to eat cheeseburgers, watch television, and get around in cars. And it's hard, says

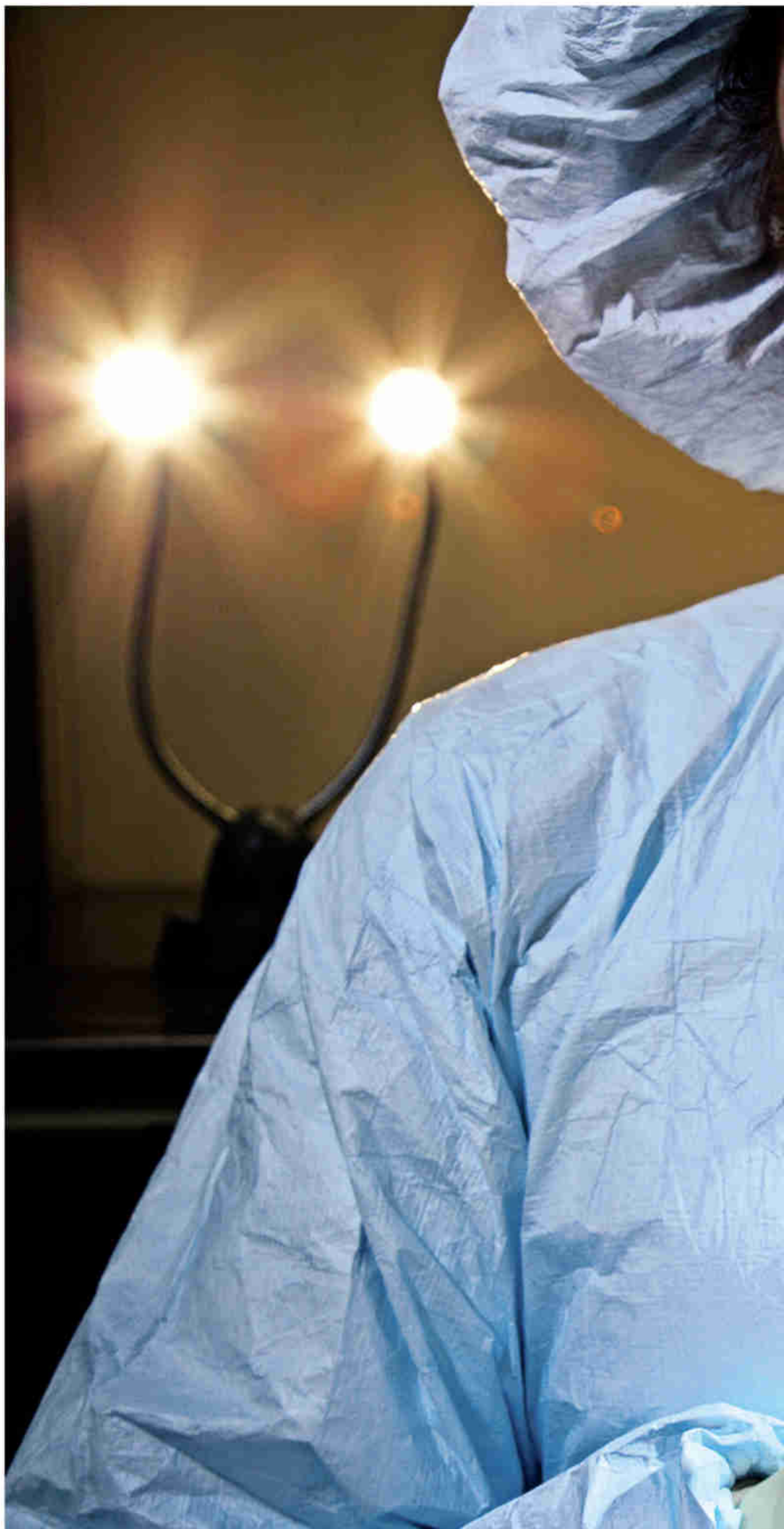
Leslie Cho, director of the Cleveland Clinic's Women's Cardiovascular Center, for a person to worry about a disease that hits ten years down the road—particularly since heart patients, unlike cancer patients, can't easily observe the progress of their disease. "You've done damage over years, and it will take years to undo that damage," she says. "That's a very hard thing to sell to Americans. We do what we can, but then people go home."

The good news is that genetic research continues to thrive. Should we want to, we will soon be able to know the state of our hearts—and our genes—in ever growing detail. That knowledge, and what we do with it, could make the difference between dying at 65 and living until 80. The choice, increasingly, will be ours.

▶ **A New Beat** See photographer Robert Clark's time-lapse photography of an innovative artificial-heart implant surgery at ngm.com/0702.

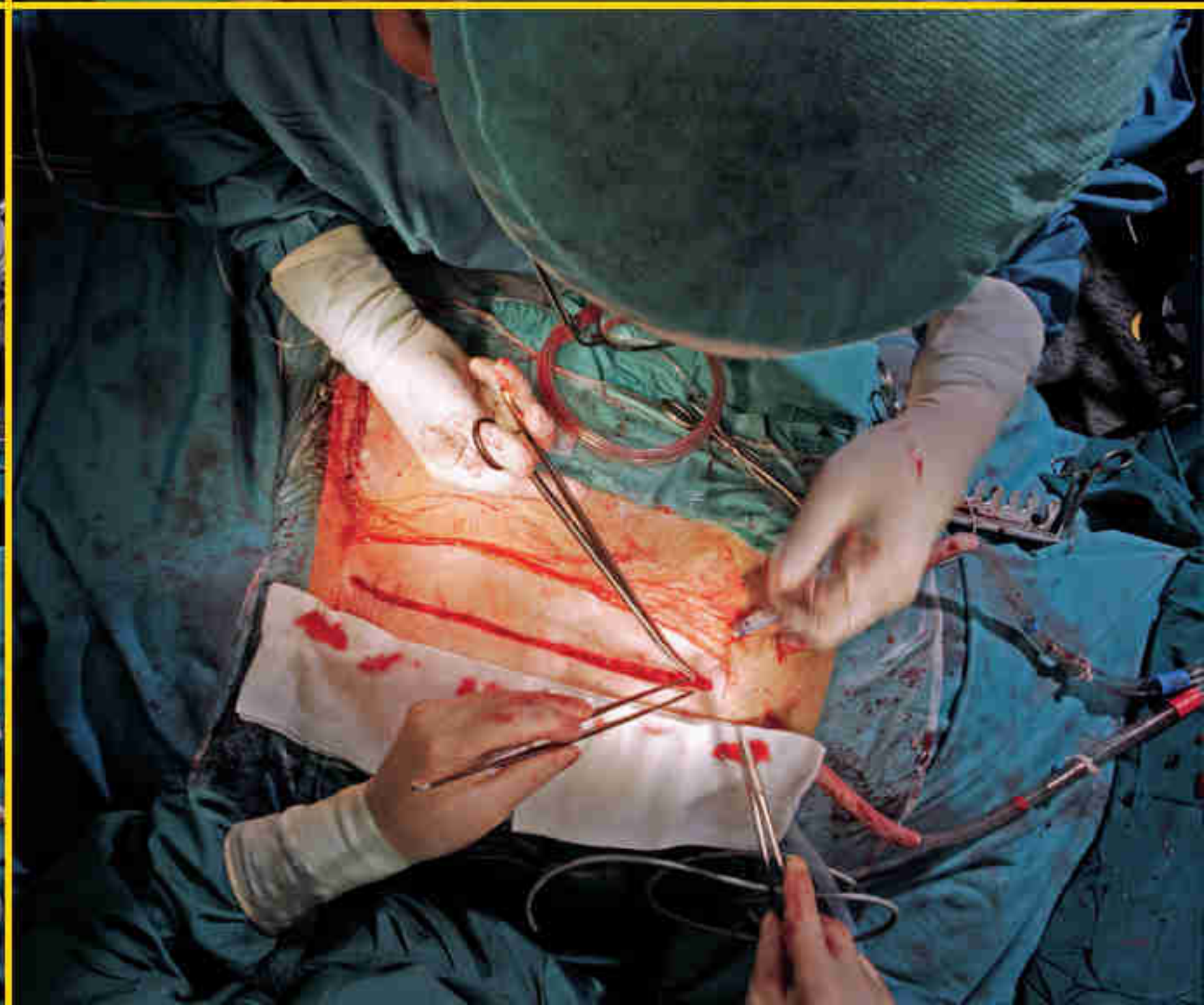
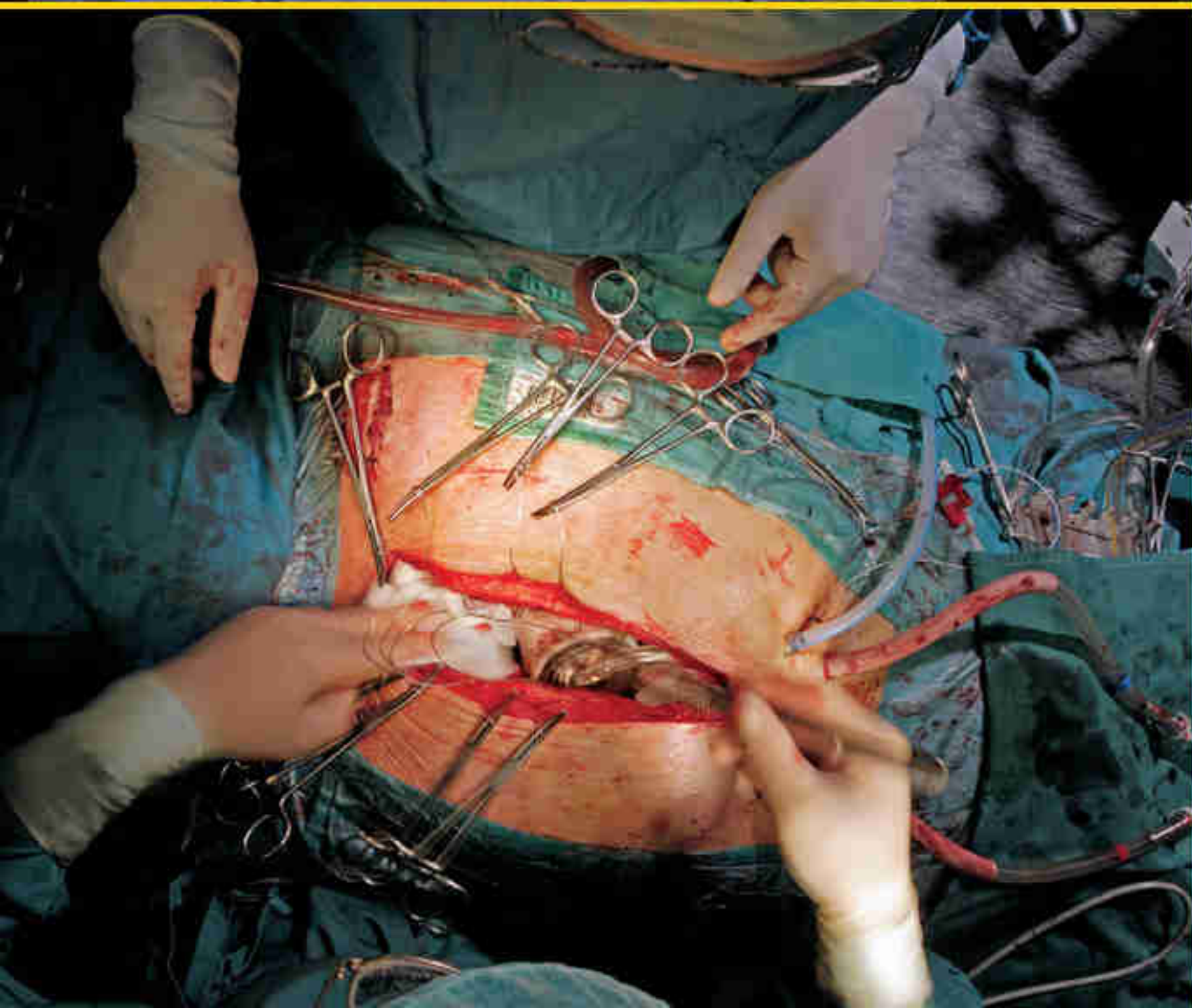
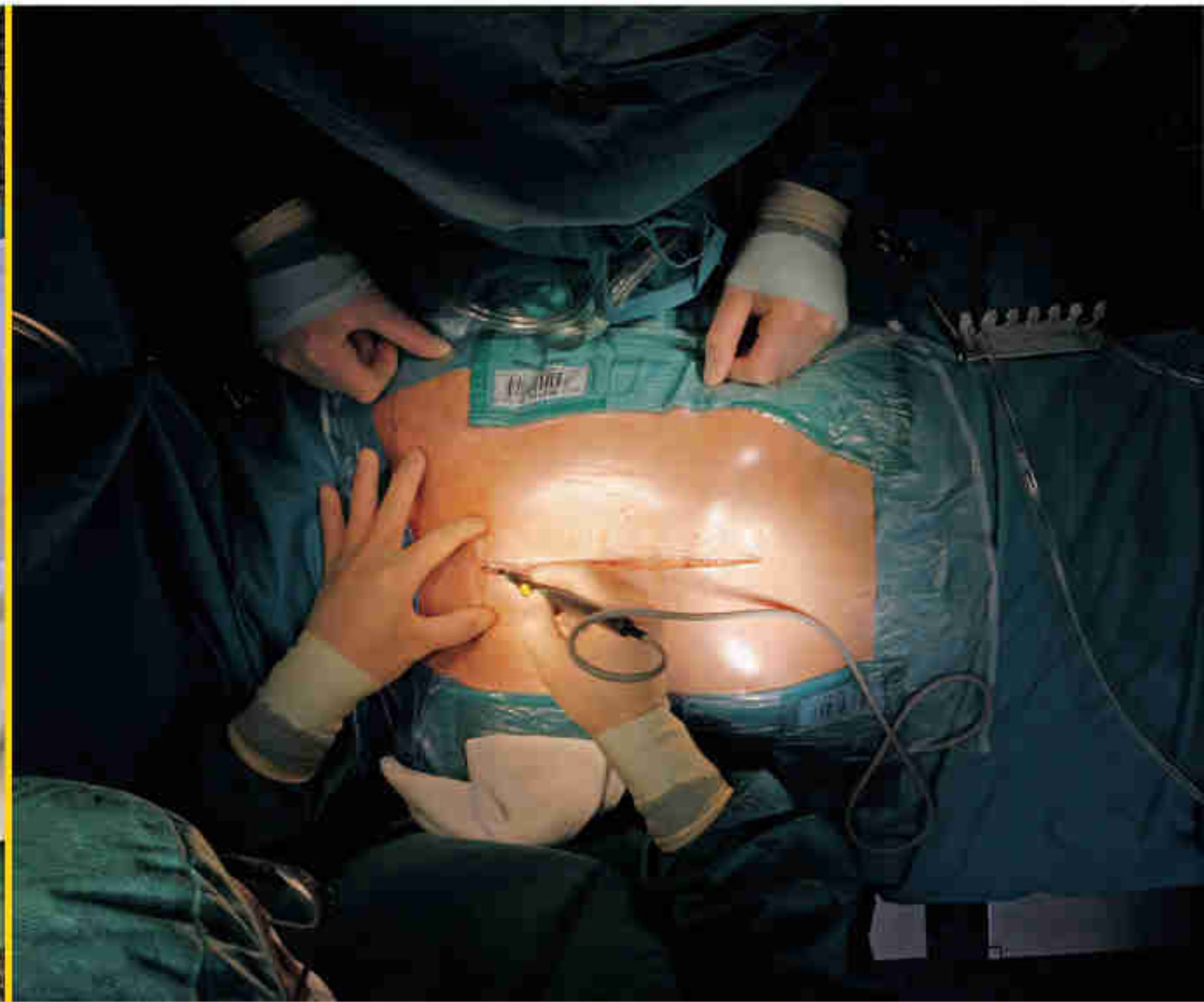
A Change of Heart

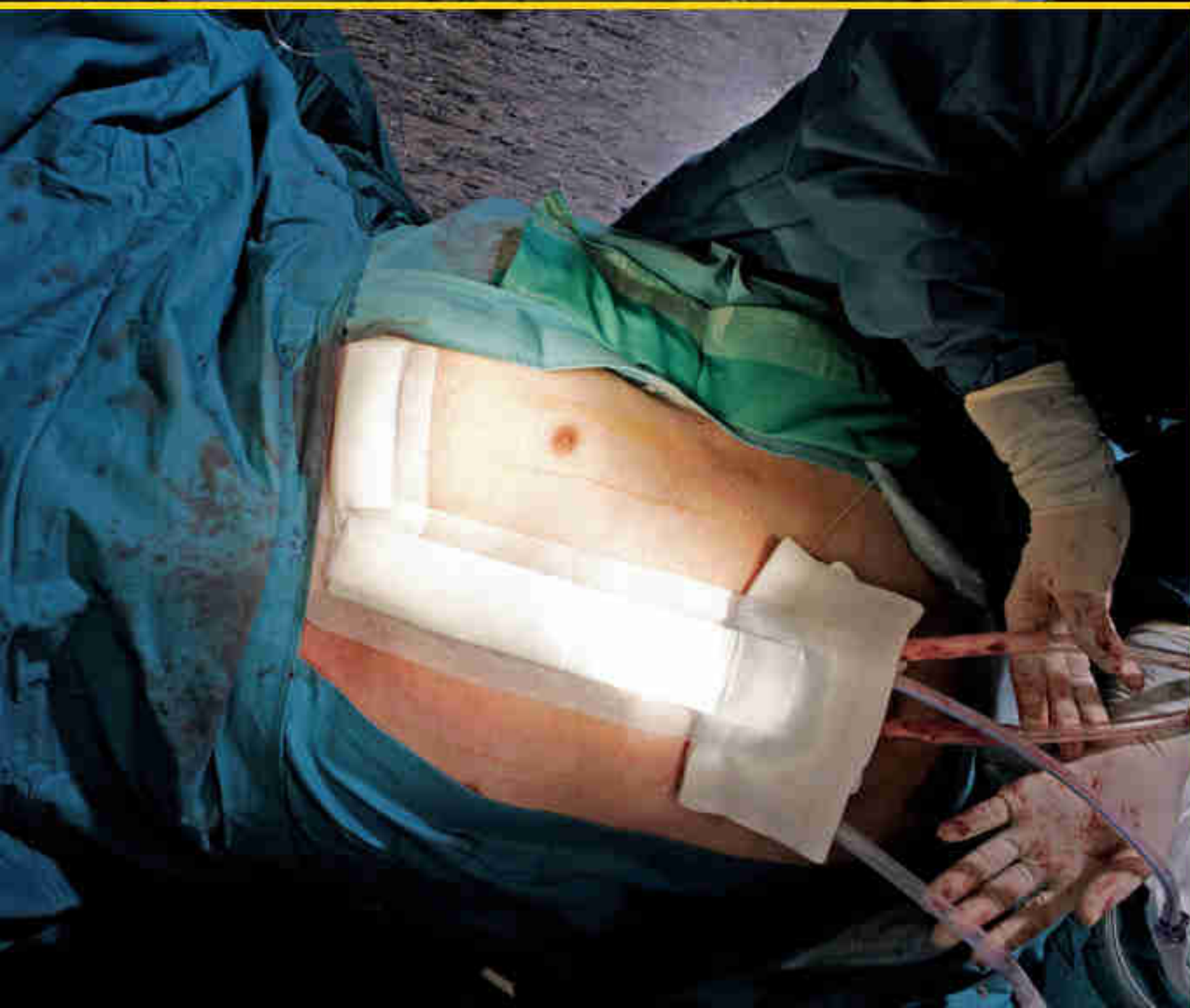
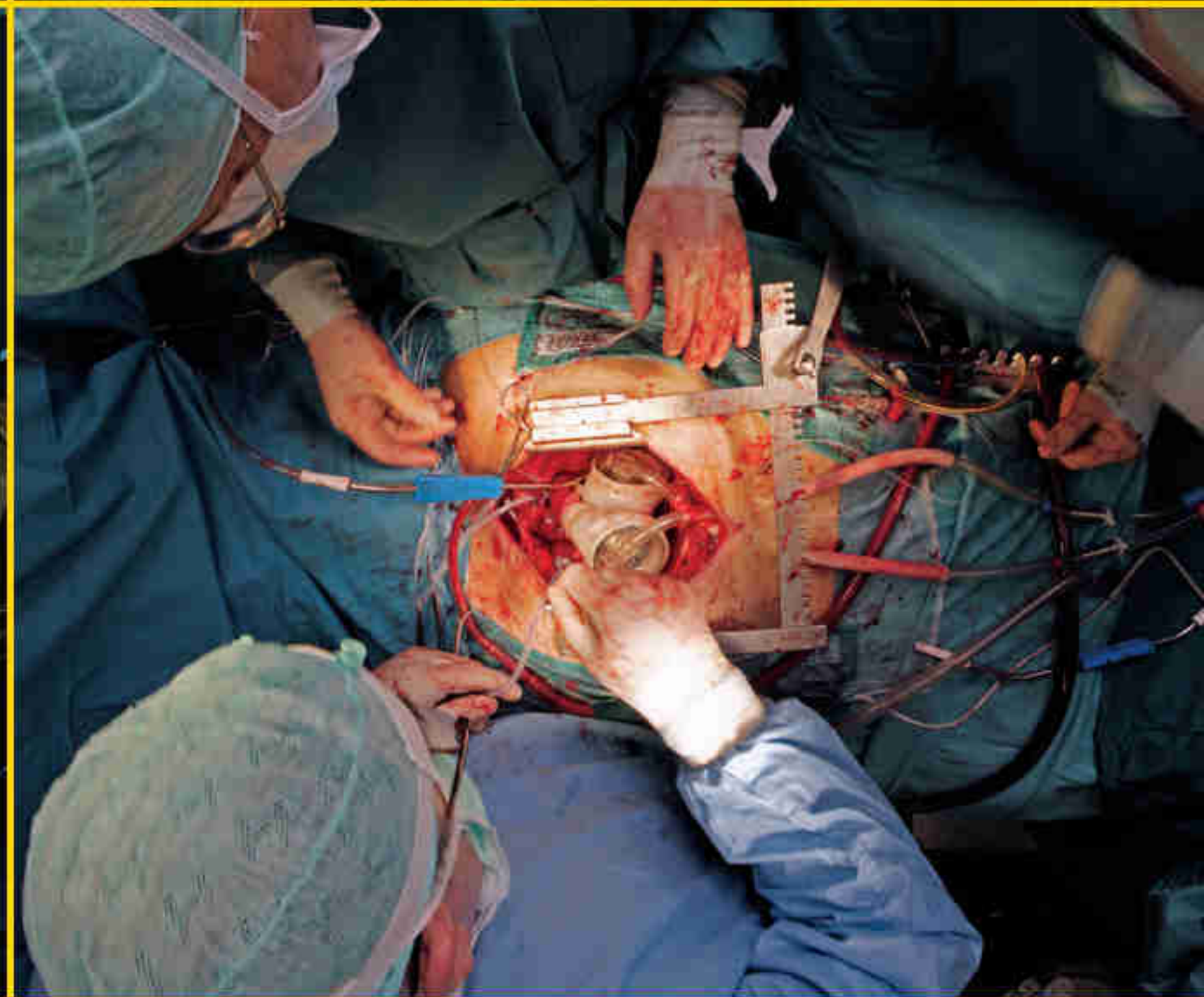
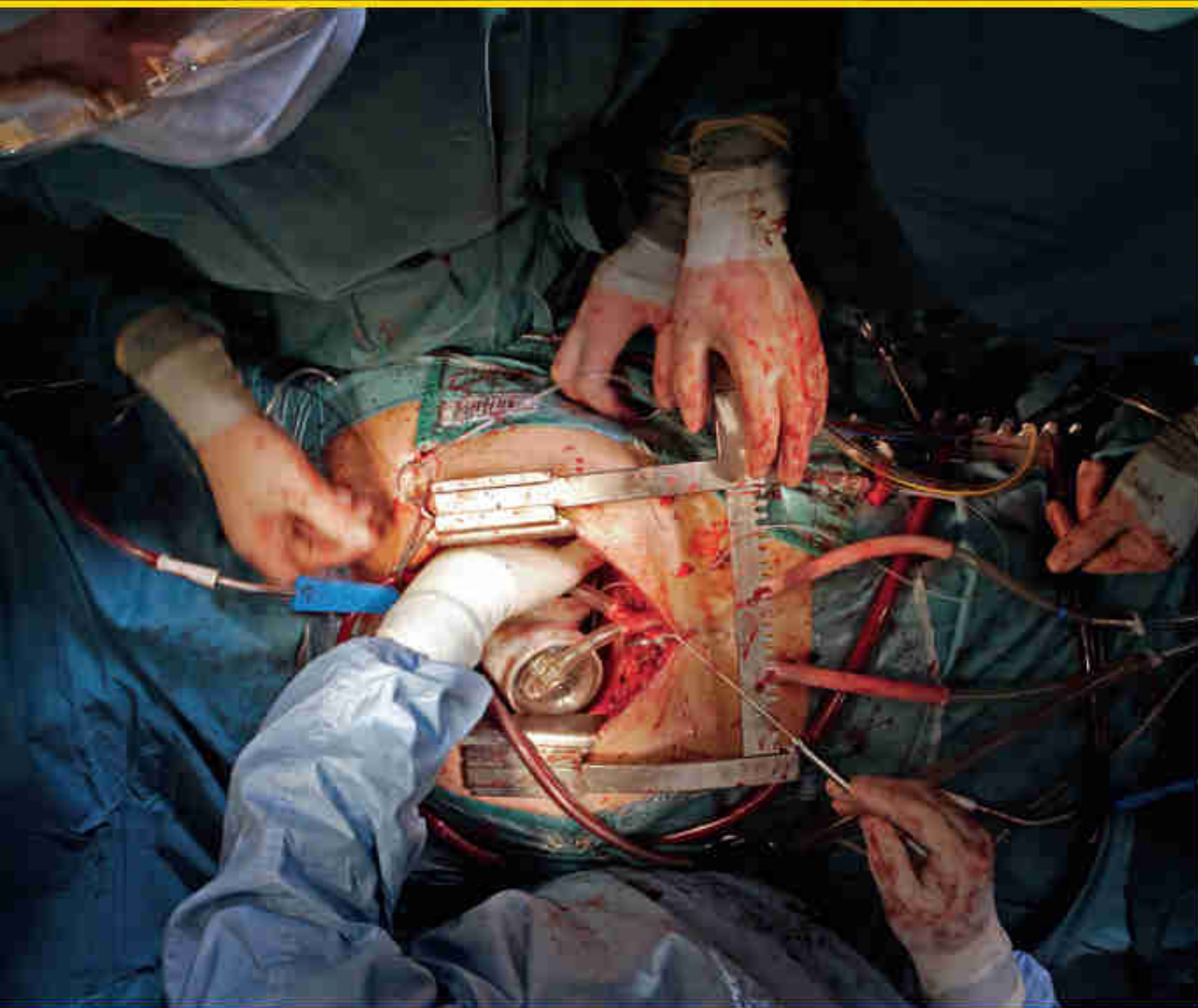
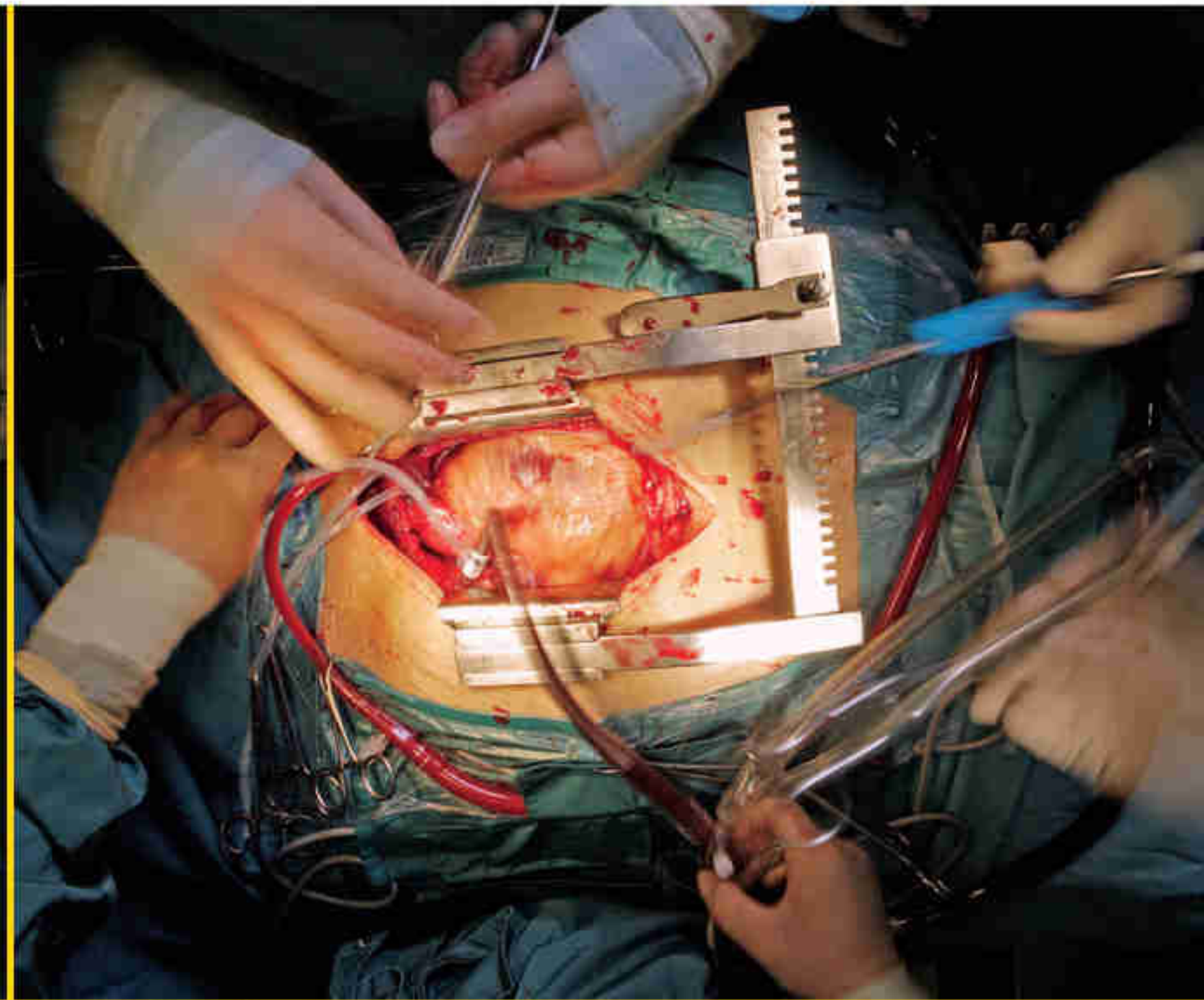
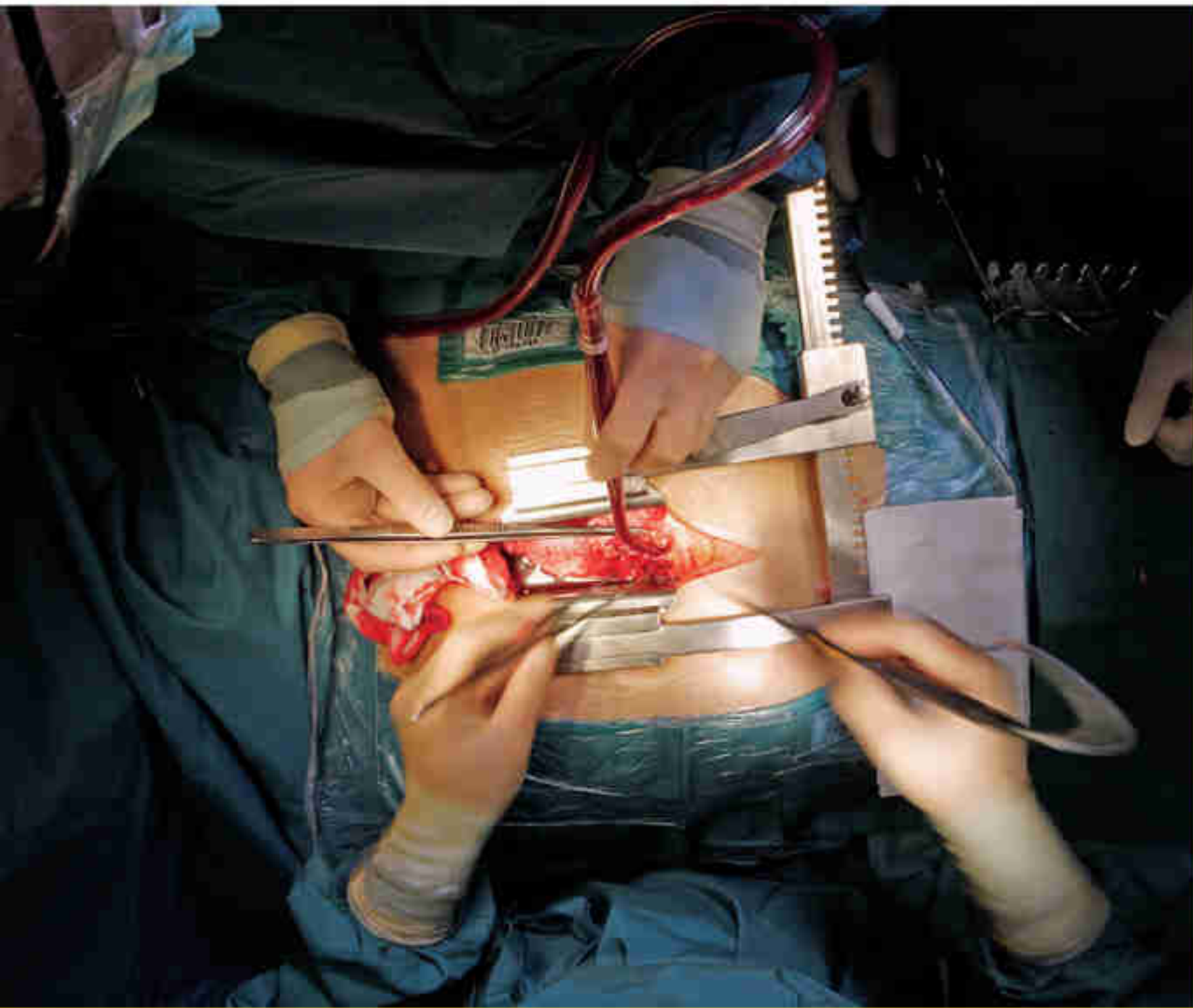
This polyurethane heart can keep critically ill cardiac patients alive while they await a donated human heart. Once the device is surgically implanted, its attached plastic tubes run through the patient's skin to a battery-powered pneumatic pump. Despite the cost—\$106,000—the demand is strong. Some 3,000 people await heart transplants in the U.S., but only about 2,100 donor hearts are available each year. While boosting the supply of artificial hearts is a relatively simple technical hurdle, increasing the supply of human hearts is more challenging. Who will be tomorrow's donors? That question lingers for a patient in Germany, who recently received a CardioWest artificial heart like this one (following pages).





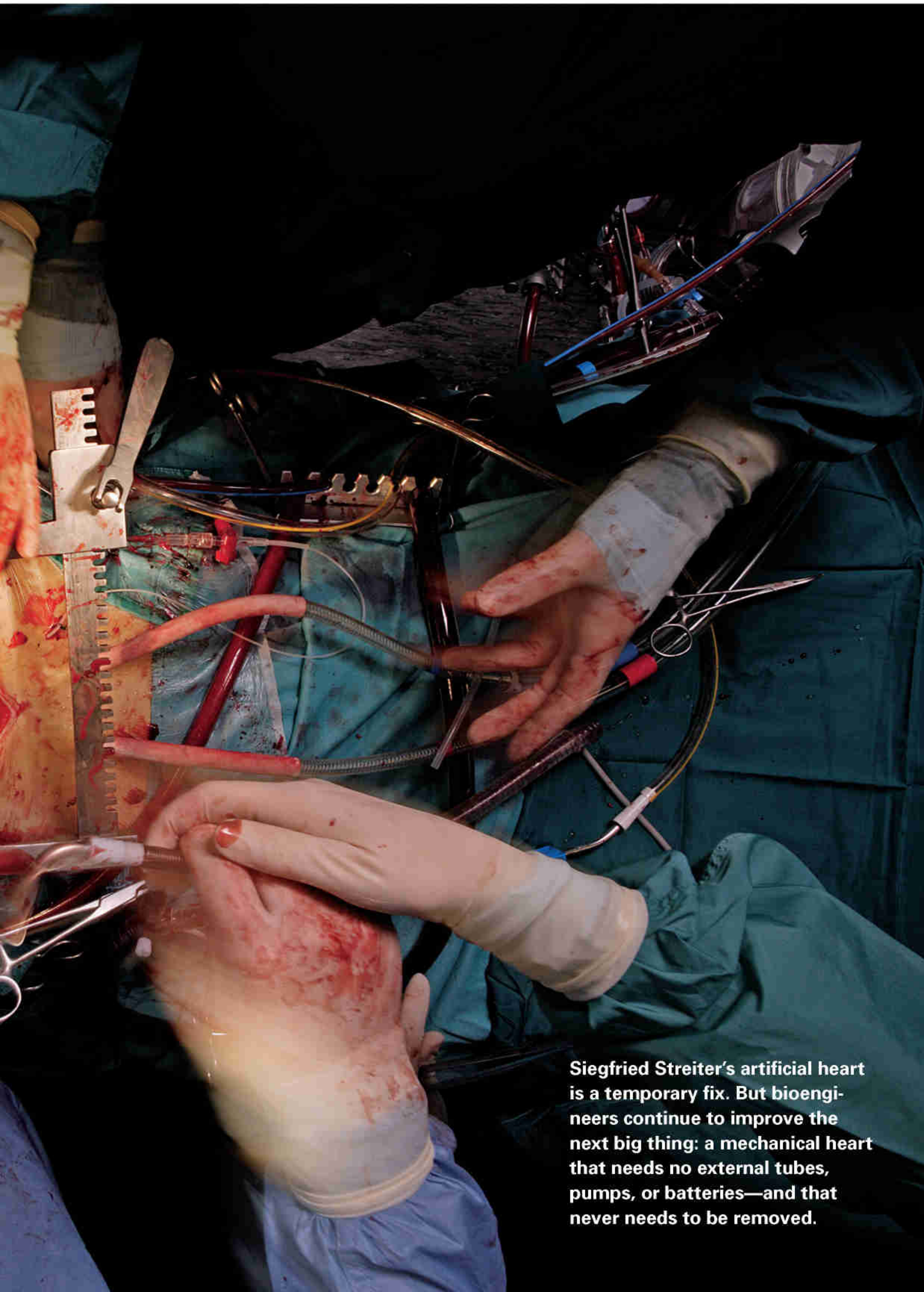
To watch a video of the transplant surgery go to ngm.com/0702.





INSTALLING A NEW PUMP, STEP-BY-STEP
At the Berlin Heart Institute in Germany, 62-year-old Siegfried Streiter endures four hours of surgery—from first incision to final sutures and bandages—to get his artificial heart. The device will not only keep him alive, says Dr. Roland Hetzer, chief surgeon; its strong, steady pulse might also help clear the chronic congestion in his lung vessels. “A transplanted human heart would have failed immediately,” says Hetzer.





Siegfried Streiter's artificial heart is a temporary fix. But bioengineers continue to improve the next big thing: a mechanical heart that needs no external tubes, pumps, or batteries—and that never needs to be removed.

gedöfnet!





Four months after receiving his artificial heart, Siegfried Streiter often gets out and about—but not without the rolling power pack that keeps the heart beating. The equipment beeps at him periodically, says Streiter, but he's not complaining. "The good news is, I'm alive." □

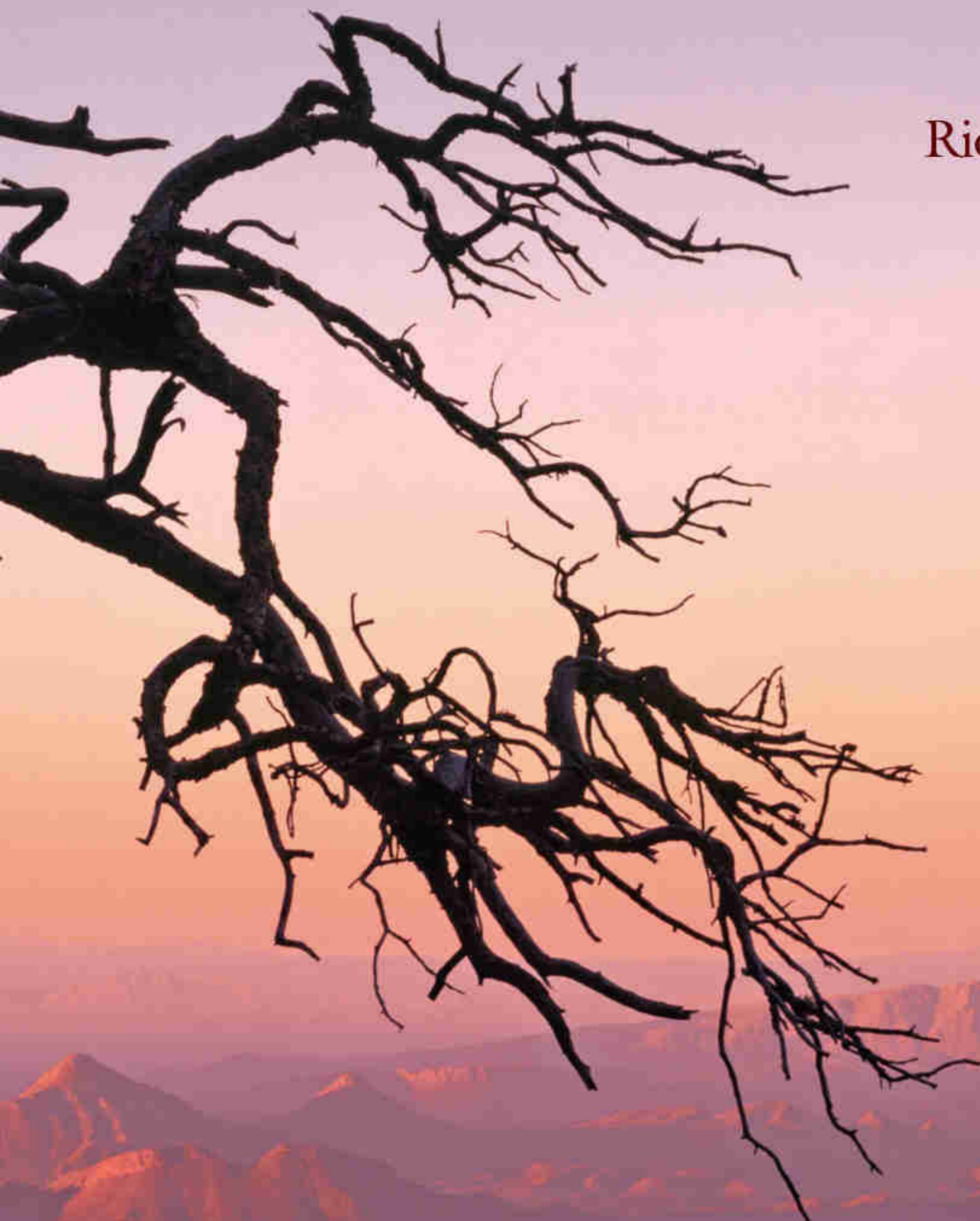


A wind-twisted piñon clings to its niche in Mexico's Sierra del Carmen, a survivor's posture in a desert revealed at daybreak in all its weathered glory.

BEYOND BIG BEND

Desolate Majesty

Shared by Texas and Mexico, shaped by the Rio Grande, this chunk of Chihuahuan Desert is a model for preserving beauty across borders.



BY JOE NICK PATOSKI

PHOTOGRAPHS BY JACK W. DYKINGA

You know you have arrived in the heart of the Chihuahuan Desert when it feels as if you have fallen off the edge of the Earth and into the rabbit hole. Nothing is as it appears. Moths are the size of hummingbirds. Are those twin pillars of black igneous rock (a landmark known as Mule Ear Peaks) ten miles away or fifty? Visibility reaches more than a hundred miles on a clear day, and since there are few roads or buildings to use as milestones, distance is difficult to judge. A jackrabbit runs so fast across the hardpan that its hind legs stretch ahead of its front ones, like in a cartoon. A black bear rambles through high desert canyons, picking its way through the yucca and prickly pear, oblivious to the fact that it seems out of place in this landscape. But that's OK. No one is around to notice.

Legend says that after God created the rest of the world, he dumped the leftovers into this giant sandbox. The devil is supposed to be sealed up in a cave on the south bank of the Río Bravo del Norte (known on the U.S. side as the Rio Grande), except when he escapes on a swing hung between nearby mountains. This is a place where water runs uphill, where rainbows have to wait for rain. The line between myth and reality blurs. Stare long enough at the Chisos Mountains or the Sierra del Carmen, the two mountain ranges, known as sky islands, that anchor the territory, and they levitate above the plain. And you haven't had a drop of tequila.

But you are under the influence of something stronger. Try inhaling the scent of creosote bushes after it rains and not feel light-headed. It is a powerful aphrodisiac. Walk across 80 miles of low and high desert, as I have, and an appreciation develops for what others might dismiss as a moonscape. Without trees or shrubs to get in the way, the view is unobstructed: 500 million years of geologic turmoil and erosion is laid bare over miles of fine sand, gravel, rocky rubble, spongy bentonite, lava spewed from volcanic eruptions.

The vast Chihuahuan Desert has long been known as El Despoblado, the land of no people. The name remains accurate today: The wildlife population still exceeds the human one. But in this part of the desert, on both sides of the border between Texas and Mexico, another name is taking hold: the El Carmen–Big Bend Transboundary Megacorridor, a label only a conservationist could love. It is two and a half million acres of one of the most biologically diverse desert regions in the world—the largest block of protected land in the Chihuahuan Desert.

The idea of preserving this place started with a dream. In the 1930s advocates in both Texas and Mexico wanted to create an international peace park. That idea never took off, but what is emerging in its place is far larger and more ambitious. On most maps, the megacorridor is blank space, the only mark a squiggly line for the river that doubles as an international boundary. It is dominated by six separate chunks of protected land that hang off the Rio Grande like clothes whipping around a clothesline. On the Mexico side, it includes the Cañón de Santa Elena in the state of Chihuahua and the Maderas del Carmen in the state of Coahuila. On the Texas side, two state protected areas flank Big Bend, a U.S. national park named for the sharp

The Rio Grande divides the washboard terrain between Texas and Mexico. Now conservationists are working to unite this biologically diverse region.



RIO GRANDE
WILD AND
SCENIC RIVER

The remoteness
is intimidating.
Bad things
happen. That
can mean a
rattlesnake bite,
a scorpion sting,
a stealth hit
by an assassin
bug. The
You Can Die
possibilities
are endless.

curve where the Rio Grande's southeasterly flow takes an abrupt turn to the north, like a car swerving to avoid an armadillo. The sixth piece is a ribbon of land on the U.S. side of the river itself.

From the air, the region is distinguished by huge cracks, crags, wrinkles, and crevices, apparently devoid of life. On the ground, it is no more welcoming. The temperature can reach over a hundred degrees on a summer day and sink below freezing on a winter night. The wind can blow 50 miles an hour for days on end. We are talking rough country. Civilization is far away, no matter what direction you came from. The remoteness is intimidating. Bad things happen. That can mean a rattlesnake bite, a scorpion sting, a stealth hit by an assassin bug. You might get stabbed by a spiny tip when you stumble into a low lechuguilla cactus, or scraped by the branches of a catclaw, or impaled by a horse creeper cactus. As locals say, if something doesn't bite, stick, or jab, it's probably a rock.

Beneath their armor, some plants possess valuable food or medicine. Take the sotol, a succulent with swordlike leaves and serrated edges, which proliferates on the high Chihuahuan Desert. Its bulbs, when baked underground for 48 hours as the ancients did, taste like steamed artichoke. The same bulbs, properly fermented into moonshine, pack a wallop similar to tequila.

There is always the chance you'll die of thirst. The You Can Die possibilities are endless, which keeps some visitors—350,000 a year to Big Bend National Park—from coming back. Those who do return are left to ponder the remarkable grit of the hardy few who have managed to survive in this spare, unforgiving environment. Not to mention the roadrunners and kangaroo rats, so adapted to the arid climate they don't even need to drink.

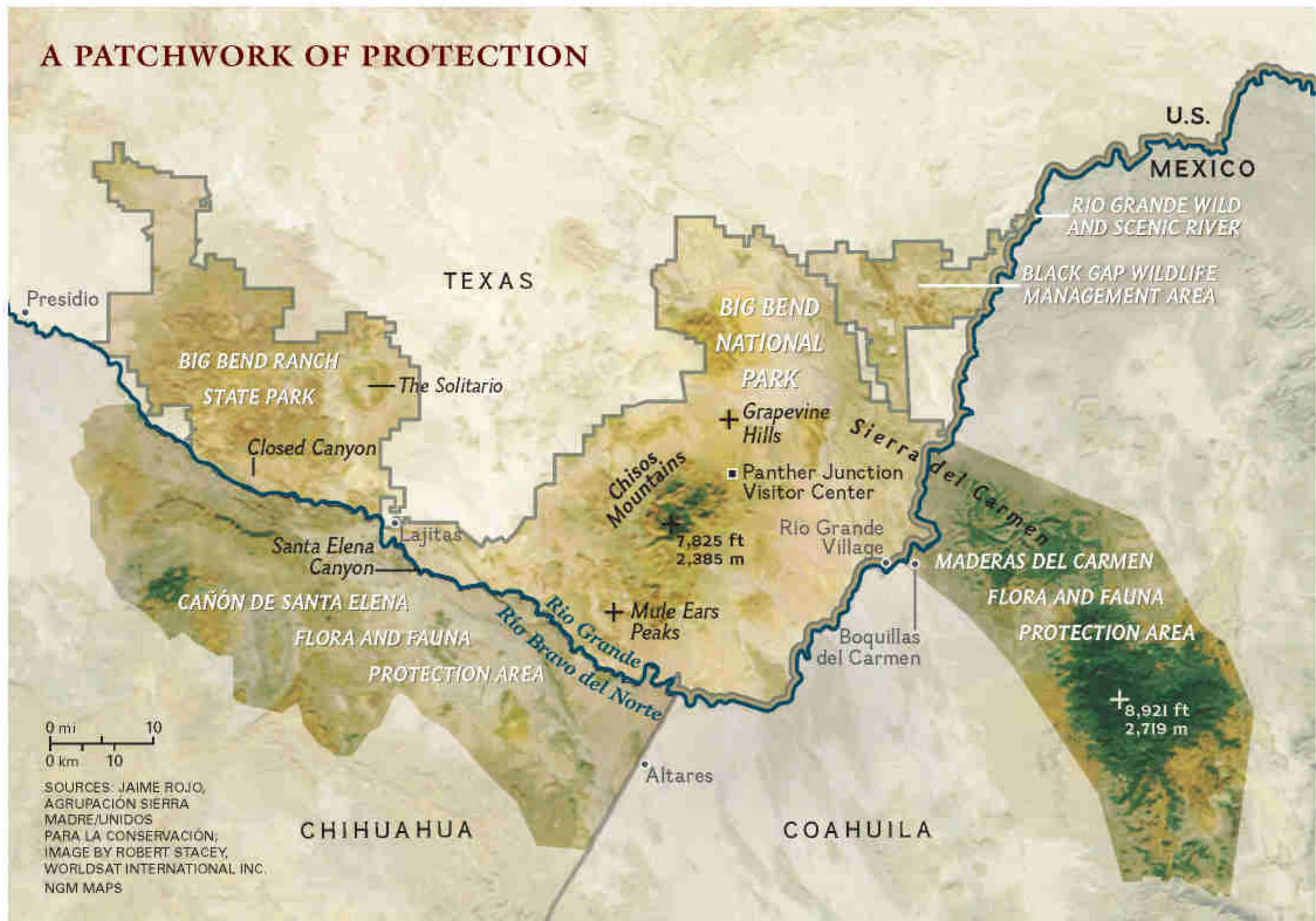
Contradictions come naturally here. The landscape is 90 percent desert yet erupts into cliffs 1,500 feet high and mountains above 8,900 feet. These skyscrapers are home to penthouse residents such as bigtooth maples, quaking aspens, and Douglas firs. They soak up water snagged from the clouds—up to 20 inches of rain a year—while their neighbors on the desert floor must make do with less than 10 inches. When it does rain, mostly during the summer “monsoons” from July through September, spindly ocotillos sprout leaves and spew flaming red shoots from the tips of their woody spines. Stalks of yucca burst with huge bouquets of tough, creamy white blossoms as big as ladling spoons. The candelabras that emerge from the heart of agaves sag heavily with radiant yellow blooms. This whole lot of nothing is full of life.

As tough as it looks, the Chihuahuan Desert is a fragile place. Few humans have stepped here, but footprints fall heavily in the desert. Since the 1800s, the region has been mined, logged, hunted, and overgrazed. Now it is being allowed to heal its wounds, helped along by governments, corporations, and individuals on both sides of the border. In 1944, Big Bend National Park was established, and a joint park with Mexico was envisioned. But it wasn't until 1994 that the Mexican government designated more than a million acres as the Cañón de Santa Elena and the Maderas del Carmen Flora and Fauna Protection Areas. In 1999, a cement company arrived on the scene, not to pave paradise but to preserve it. Cemex, the Mexican cementmaker with operations in 50 countries, has purchased hundreds of thousands of acres along the border to set aside for preservation.

This is a different model of conservation. Mexico lacks the funds to purchase land for parks or wildlife habitat, a situation becoming increasingly common in the United States. So on the Mexico side of the corridor, much of the protected land is privately owned. Mining has been allowed to

continue. Rather than removing the 5,000 ranchers and farmers living within the protected areas, as U.S. national parks historically have done, conservationists are teaching them why it's in their interest to protect the land. The goal is to give residents a sense of stewardship that national parks do not. "You have to understand, the concept of wilderness doesn't presently exist in Mexico," says Patricio Robles Gil, an environmentalist and architect of the partnership with Cemex. "In Spanish, we don't have a word for wilderness. This is all new, but it could be the model beyond a national park."

After a long day working in the desert, a group of conservationists gathers for a dinner of steaks and tortillas at the Cemex reserve's main lodge. There



is talk of the future. Already, a couple of adjacent areas are being proposed to join the two protected areas on the Mexican side. They discuss reintroducing the grizzly bear, the Mexican gray wolf, and bison—all believed to have been native to the area. Anywhere else, such talk would be dismissed as a fairy tale. In the Transboundary Megacorridor, such dreams seem possible.

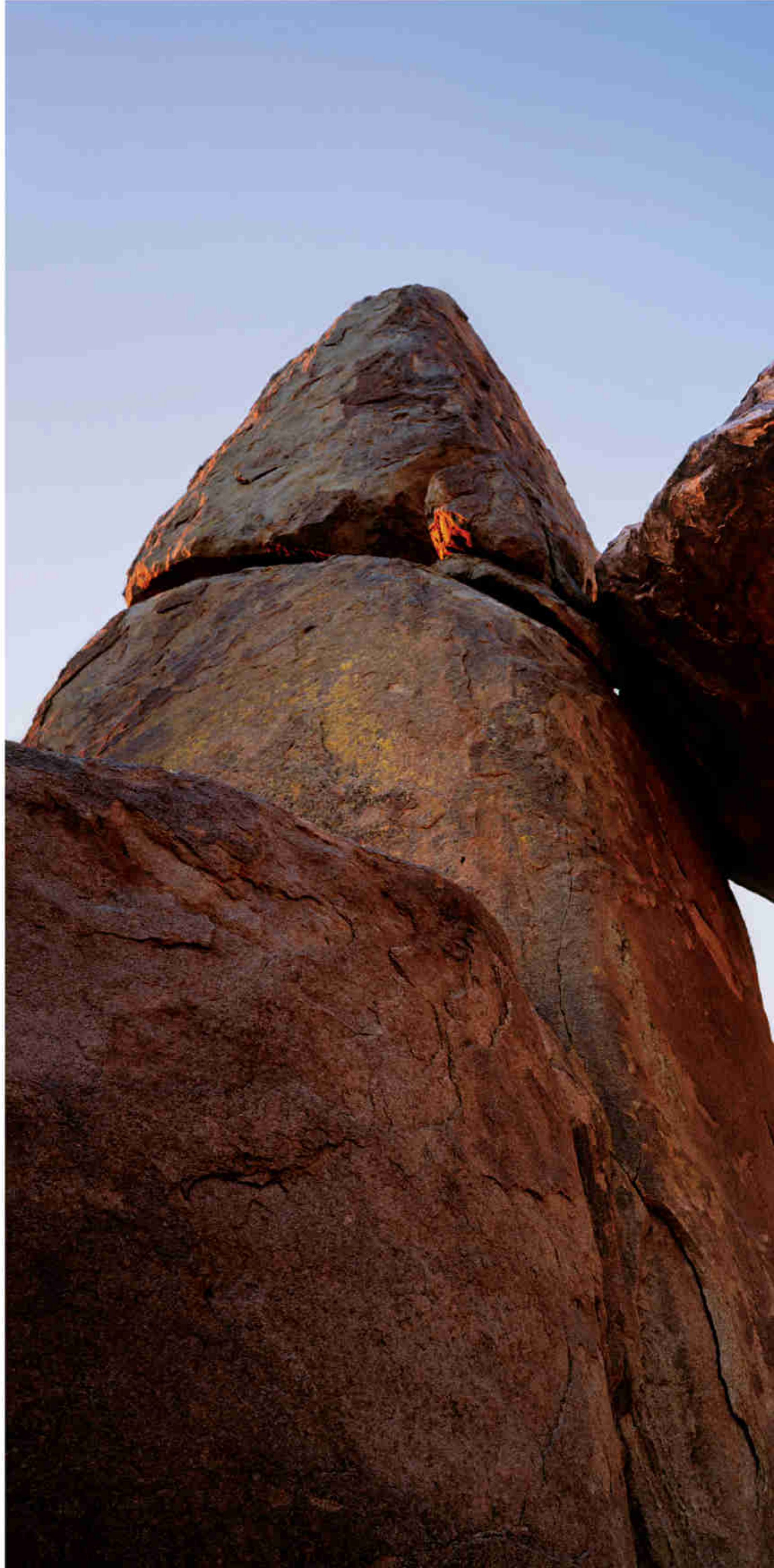
And why not? The desert bighorn sheep has been reestablished, as has the pronghorn antelope. Decades ago, only a few remaining black bears could be found tucked away in the isolated mountain ranges of Coahuila. A group of Mexican ranchers decided to quit hunting bears and start protecting them instead. Now you see black bears on the Texas side of the river again. Wildlife pays no attention to international boundaries.

To its true believers, the megacorridor is the whole world boiled down to its essence. It is "pure raw," says a conservationist who has fallen under its spell, one of the last places on the North American continent where wild trumps humanity, and one of the only spots where wilderness is actually expanding instead of contracting. At a time when most of the Earth's stories focus on what is being lost, that is a contradiction worth celebrating.

Six government protected areas anchor the El Carmen–Big Bend Transboundary Megacorridor, the largest protected swath of the Chihuahuan Desert.

BIG BEND NATIONAL PARK

A balancing act long in the making, a car-size rock formation could slip tomorrow or sit this way for thousands more years in the Grapevine Hills of Big Bend National Park, the largest of the protected areas. Volcanic history has studded the park with monumental earthworks, still visited by tremors—and 350,000 tourists a year.





BIG BEND NATIONAL PARK



The Chisos Mountains, rising more than 7,500 feet, form the heart of the national park and monopolize most of its precipitation, snagging quick-moving tides of fog (top right). Despite the tease of dusk clouds (left), rain stays a stranger in the lowland desert of the park's western edge; an ocotillo is the lone sign of life on a ridge strewn with ancient lava. Judging from the plump blades of an *Agave havardiana*, or century plant (bottom right), rain has blessed this spot.



BLACK GAP WILDLIFE MANAGEMENT AREA





Ground truth is harsh in Black Gap, with some of the lowest elevations in the Chihuahuan Desert: scant trails and water, scrubby brush hiding snakes and scorpions, sun-roasted surfaces with no shade. Seen from on high, however, land near the Rio Grande appears cool and serene, with marble-like swirls and waves. The patterns derive from limestone eroding at a slower rate than surrounding clays. A hiker might miss the camouflaged living rock cactus (above), if not for its short-lived bloom in autumn.

BIG BEND RANCH STATE PARK



With its longhorn roundups, this former cattle farm is still more ranch than park. But traces of humans—ranching roads, mine shafts—are mere dustings compared with the imprint left by volcanic explosions. Broken-toothed snags surround the caldera of the Solitario (above), where the earth split open 36 million years ago. Similar eruptions left their script in ash, mud, and river deposits, which layer a cliff near a wind-rustled ocotillo (right).





BIG BEND RANCH STATE PARK





A rain puddle reflects a cliff lit by morning sun in the depths of Closed Canyon. Wetter than the national park next door, this area is fed by scores of year-round springs and some of Texas' highest waterfalls. Hikers find refuge from the sun in this narrow cut in the rock. But no desert place is risk-free. Flash floods barrel through here, scouring the canyon floor.

CAÑÓN DE SANTA ELENA PROTECTION AREA





Across the border, spines on a clump of prickly pear cactus serve notice that Mexico's Santa Elena Canyon country does not suffer fools. A series of mountains connect across a stretch of desert that, while protected, is still largely owned by private ranchers and *ejidos*, or farming cooperatives—a common situation in Mexican conservation. Surprises await, like a cascade-fed pool. Swimmers beware: Cattle use it as a watering hole.

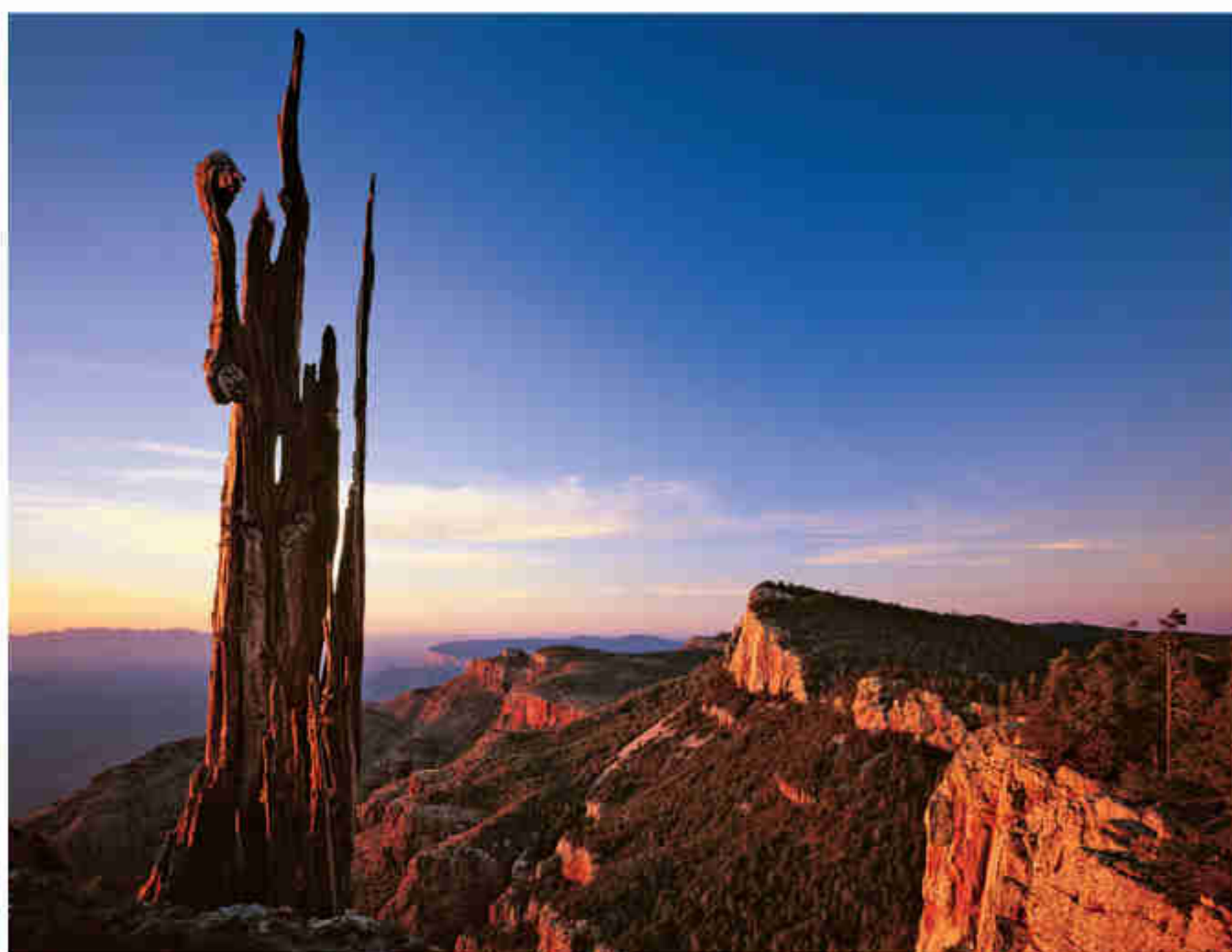
MADERAS DEL CARMEN PROTECTION AREA

A showy bloom of sotol produces a thicket of flowering stalks in the Maderas del Carmen, noted for its "sky island" that rises 8,900 feet from the desert floor. High elevation means water is abundant, supporting greater plant diversity and animal life than on the Texas side of the border. But, again, a different model of conservation is at work here: The private cement firm, Cemex, has purchased some 375,000 acres and hopes to restore the ranched and logged land.





MADERAS DEL CARMEN PROTECTION AREA



Roaring out of Texas, a spring storm advances on a beaked yucca flowering on a Mexican slope (right). The region's intricate canyons serve as a drainage system to lead heavy rains to the desert floor. Higher up in the Carmen, grass as thick as a horse's mane flows with the wind past a dead agave (top left). And from atop a forested escarpment, a conifer snag is the perfect spot for viewing the light show of sunset, a daily celebration in the Big Bend wilds. □

➤ **Around the Bend** See more compelling images of Big Bend beauty in our Photo Gallery at ngm.com/0702.



CURSE OF THE BLACK GOLD HOPE AND



BETRAYAL IN THE NIGER DELTA

A photograph capturing a scene of environmental and social decay in Port Harcourt, Nigeria. The foreground is dominated by a shantytown with makeshift buildings constructed from corrugated metal and wood, situated along a riverbank. The roofs are uneven and some are partially collapsed. In the background, a large plume of thick, black smoke rises into a clear blue sky, originating from a slaughterhouse. The smoke drifts over the shantytown, creating a hazy atmosphere. The water in the foreground reflects the buildings and the smoke, adding to the somber mood of the image.

After 50 years of oil, Port Harcourt in southern Nigeria still looks and smells like a shantytown. Smoke from a slaughterhouse drifts over shops thrown up on a riverbank.



Twenty miles—and a world away—from strife-torn oil fields on land, a rig operated by Total, a French multinational, draws oil from a newly tapped deposit in the Gulf of Guinea.







Fighters with MEND (Movement for the Emancipation of the Niger Delta) brandish weapons near their camp. Insurgents vow to shut off the oil if calls for local control of resources aren't met.





Ebia Amakadou, 18, watches over her sleeping two-year-old son in the village of Oweikorogba. Like most delta settlements, the village has no power or clean water.



Dockhands push a barrel of gasoline to a black-market distributor in Yenagoa. Despite its large oil reserves, Nigeria lacks functioning refineries and often suffers fuel shortages.

By Tom O'Neill

NATIONAL GEOGRAPHIC STAFF

Photographs by Ed Kashi

Oil fouls everything in southern Nigeria. It spills from the pipelines, poisoning soil and water. It stains the hands of politicians and generals, who siphon off its profits. It taints the ambitions of the young, who will try anything to scoop up a share of the liquid riches—fire a gun, sabotage a pipeline, kidnap a foreigner.

Nigeria had all the makings of an uplifting tale: poor African nation blessed with enormous sudden wealth. Visions of prosperity rose with the same force as the oil that first gushed from the Niger Delta's marshy ground in 1956. The world market craved delta crude, a "sweet," low-sulfur liquid called Bonny Light, easily refined into gasoline and diesel. By the mid-1970s, Nigeria had joined OPEC (Organization of Petroleum Exporting Countries), and the government's budget bulged with petrodollars.

Everything looked possible—but everything went wrong.

Dense, garbage-heaped slums stretch for miles. Choking black smoke from an open-air slaughterhouse rolls over housetops. Streets are cratered with potholes and ruts. Vicious gangs roam school grounds. Peddlers and beggars rush up to vehicles stalled in gas lines. This is Port Harcourt, Nigeria's oil hub, capital of Rivers state, smack-dab in the middle of oil reserves bigger than the United States' and Mexico's combined. Port Harcourt should gleam; instead, it rots.

Beyond the city, within the labyrinth of creeks,

rivers, and pipeline channels that vein the delta—one of the world's largest wetlands—exists a netherworld. Villages and towns cling to the banks, little more than heaps of mud-walled huts and rusty shacks. Groups of hungry, half-naked children and sullen, idle adults wander dirt paths. There is no electricity, no clean water, no medicine, no schools. Fishing nets hang dry; dugout canoes sit unused on muddy banks. Decades of oil spills, acid rain from gas flares, and the stripping away of mangroves for pipelines have killed off fish.

Nigeria has been subverted by the very thing that gave it promise—oil, which accounts for 95 percent of the country's export earnings and 80 percent of its revenue. In 1960, agricultural products such as palm oil and cacao beans made up nearly all Nigeria's exports; today, they barely register as trade items, and Africa's most populous country, with 130 million people, has gone from being self-sufficient in food to importing more than it produces. Because its refineries are constantly breaking down, oil-rich Nigeria must also import the bulk of its fuel. But even then, gas stations are often closed for want of supply. A recent United Nations report shows that in quality of life, Nigeria rates below all other major oil nations, from Libya to Indonesia. Its annual per capita income of \$1,400 is less than that of Senegal, which exports mainly fish and nuts. The World Bank categorizes Nigeria as a "fragile state," beset by risk of armed conflict, epidemic disease, and failed governance.

The sense of relentless crisis has deepened since last year, when a secretive group of armed, hooded rebels operating under the name of the Movement for the Emancipation of the



Niger Delta, or MEND, intensified attacks on oil platforms and pumping stations, most operated by Shell Nigeria. Militants from MEND and other groups have killed soldiers and security guards, kidnapped foreign oil workers, set off car bombs in the delta city of Warri to protest the visit of Chinese oil executives, and, to show off their reach, overrun an oil rig 40 miles offshore in the Gulf of Guinea. The attacks have shut down the daily flow of more than 500,000 barrels of oil, leading the country to tap offshore reserves to make up for lost revenue. With each disruption, the daily price of oil on the world market climbed. According to the Brussels-based International Crisis Group, escalating violence

in a region teeming with angry, frustrated people is creating a “militant time bomb.”

From a potential model nation, Nigeria has become a dangerous country, addicted to oil money, with people increasingly willing to turn to corruption, sabotage, and murder to get a fix of the wealth. The cruelest twist is that half a century of oil extraction in the delta has failed to make the lives of the people better. Instead, they are poorer still, and hopeless.

Every day at Bonny Island, oceangoing tankers line up in Cawthorne Channel like massive parade floats. They’re each waiting to fill up with close to a million barrels



From a potential model nation, Nigeria has become a dangerous country, addicted to oil money.

Uprooted to make room for a liquefied natural gas plant, people in the village of Finima on Bonny Island complain that the facility has damaged fishing grounds, with few jobs offered in return.

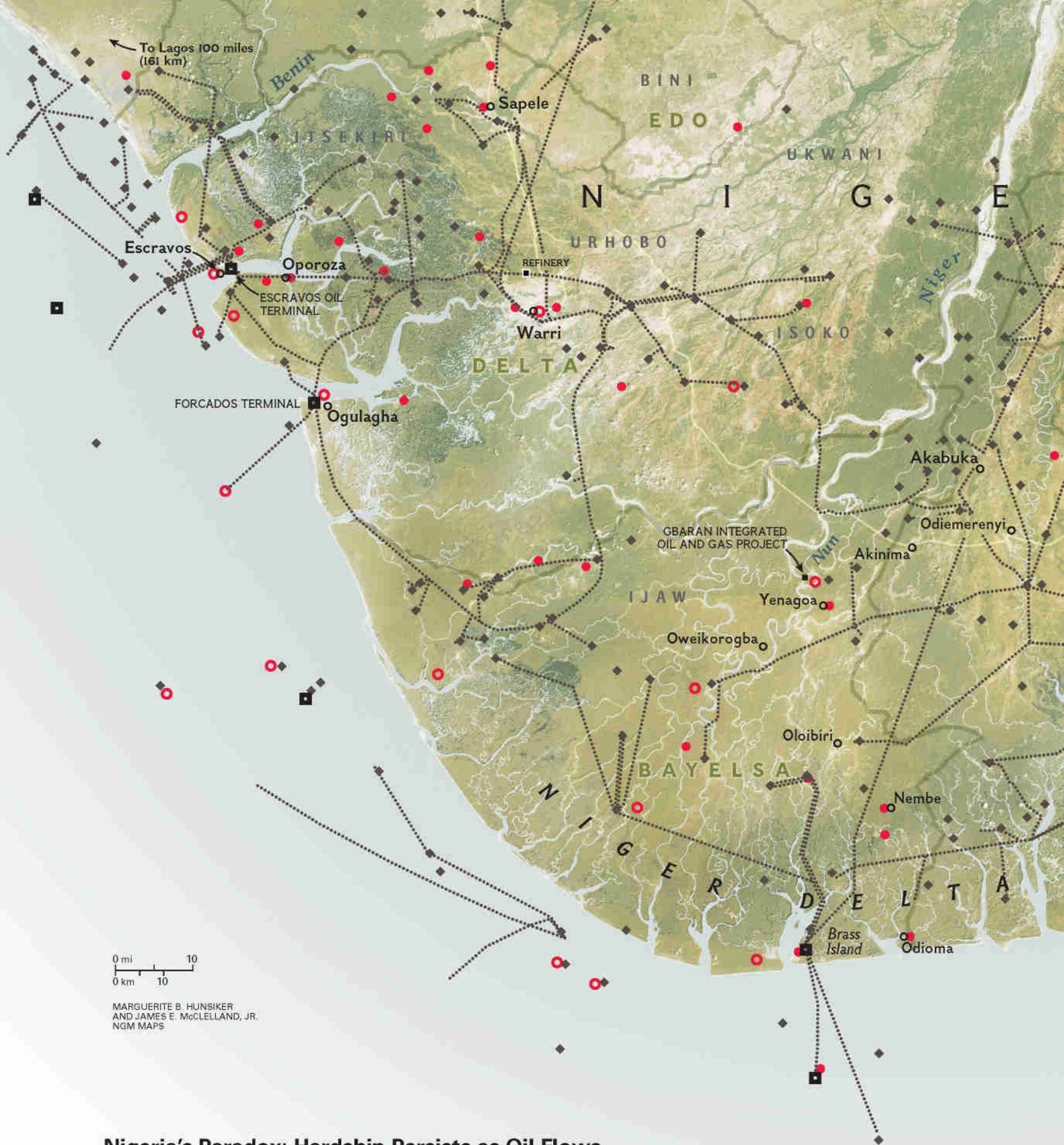
of the coveted Bonny Light, drawing the oil from a nearby export terminal. Ships have been gathering at this 15-mile-long barrier island since the mid-1500s, when slave trading between West Africa and the New World began. Beneath the contemporary cacophony—the yammer of motorcycle taxis, the call of Christian preachers from the market stalls, the throb of drums and guitars from boomboxes inside shacks—strains of anger and sorrow echo the tragedy of exploitation.

“It’s not fair,” Felix James Harry muttered in a meetinghouse in the village of Finima on the western end of the island, close to the oil and gas complex. “We can hardly catch fish anymore.

Surviving is very hard.” Harry, a 30-year-old father of two children, should have been in his canoe this afternoon, throwing out nets to snare crayfish and sardines. But he was sitting in an airless concrete-block shelter with half a dozen other fishermen, none of whom had much to do.

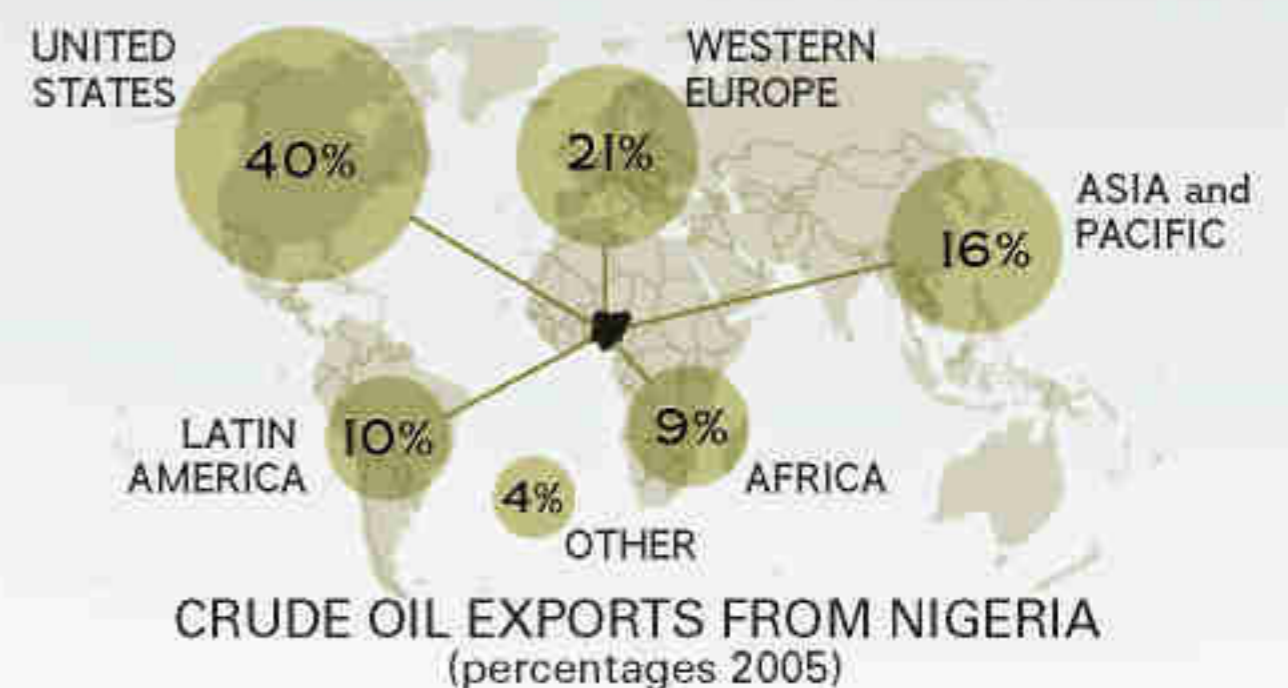
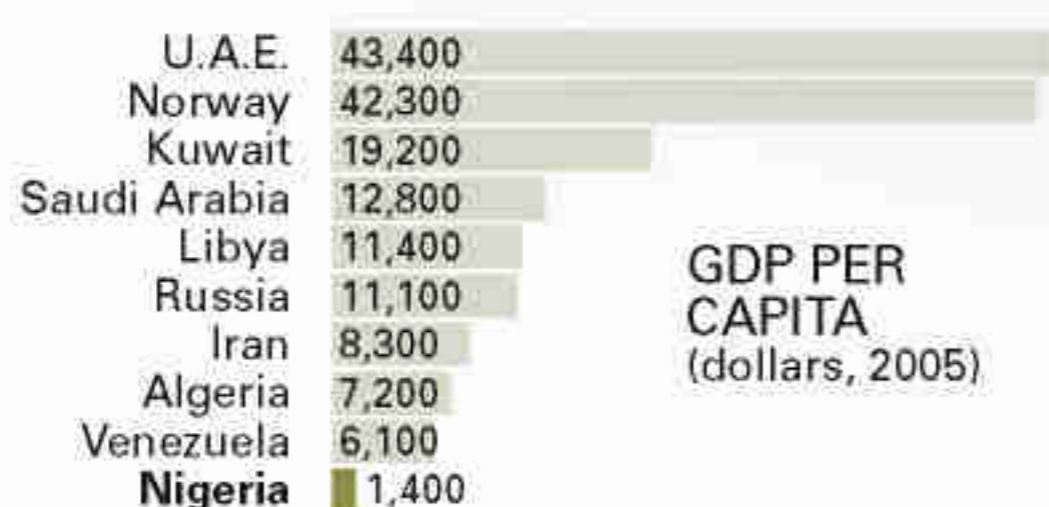
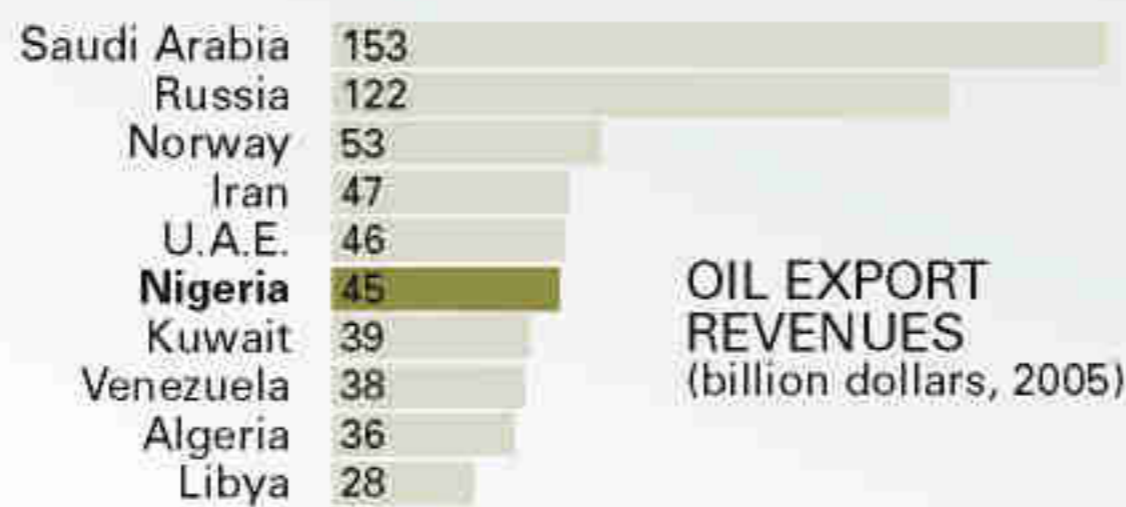
Their fishing community once stood on the other side of a small inlet, where fuel storage tanks the size of cathedral domes now loom, and where the superstructure of a liquefied natural gas plant juts higher than any tree in the forest. The relocation of Finima in the early 1990s jarred loose the community’s economic moorings. “We can’t support our families anymore,” Harry said.

Houses in the new village are tightly packed, leaving little room for gardens. Windows look out on walls. In this claustrophobic setting, the men talked about nature. “The forest where the gas plant is protected us from the east wind,” Solomon David, the community chairman, said. “Now, the rain and wind ruin our thatched roofs every three months. They lasted more than twice as long before.” Another fisherman mentioned how construction and increased ship traffic changed local wave patterns, causing shore erosion and forcing fish into deeper water. “We would need a 55-horsepower engine to get to those places.” No one in the room could afford such an engine.

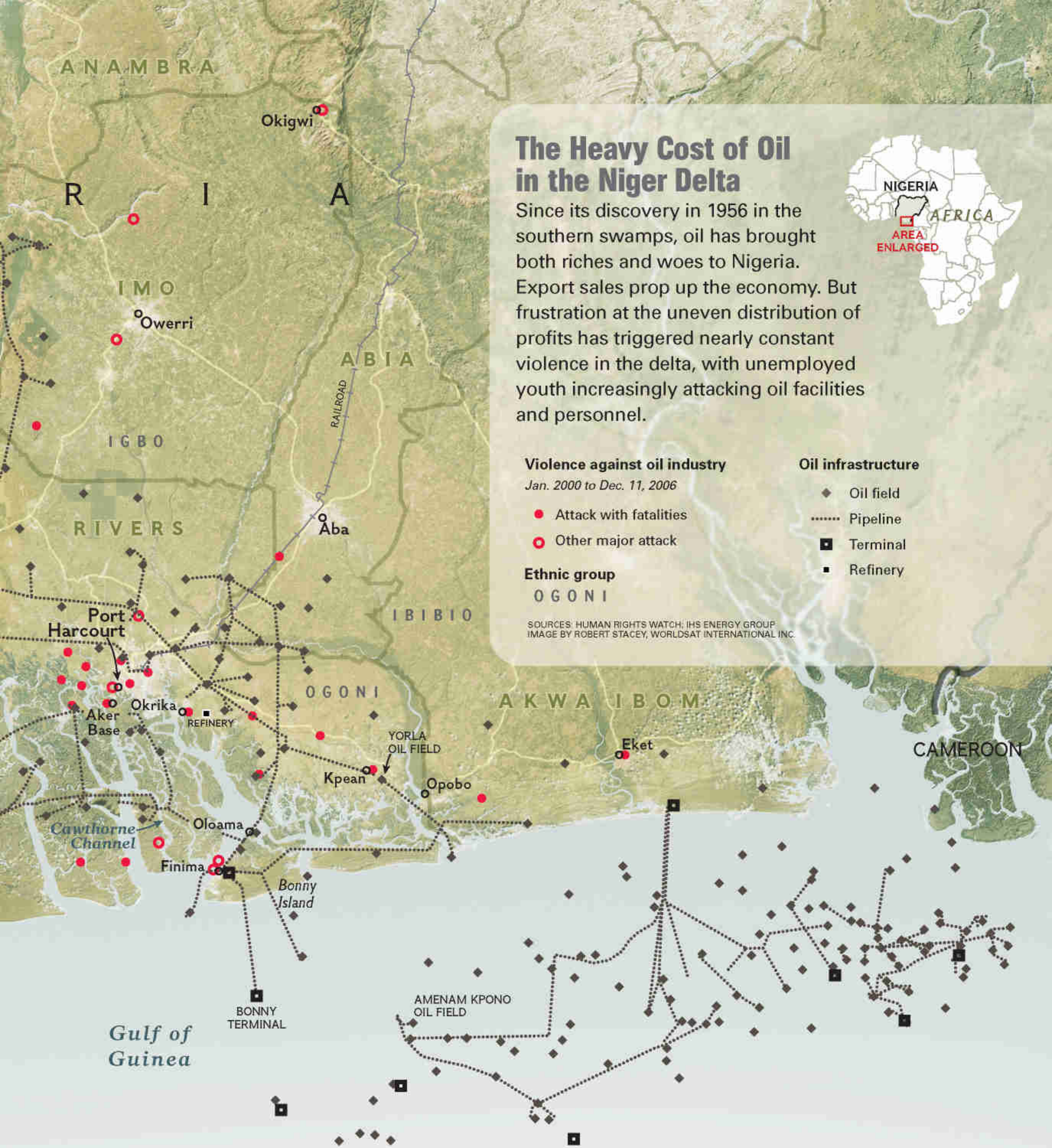


Nigeria's Paradox: Hardship Persists as Oil Flows

Despite its ranking as the world's sixth largest oil exporter and Africa's top producer, Nigeria falls behind major oil nations in alleviating poverty. Corruption siphons off as much as 70 percent of annual oil revenues; most Nigerians live on less than a dollar a day. Blame for the lack of development lies with the multinational oil firms and the government, partners in onshore operations.



Its low-sulfur Bonny Light crude covered the world over, Nigeria exports up to 2.5 million barrels of oil a day, most to the U.S. and Europe. Insurgent attacks in 2006 regularly cut exports.



The Heavy Cost of Oil in the Niger Delta

Since its discovery in 1956 in the southern swamps, oil has brought both riches and woes to Nigeria. Export sales prop up the economy. But frustration at the uneven distribution of profits has triggered nearly constant violence in the delta, with unemployed youth increasingly attacking oil facilities and personnel.

Violence against oil industry

Jan. 2000 to Dec. 11, 2006

- Attack with fatalities
- Other major attack

Ethnic group

OGONI

Oil infrastructure

- ◆ Oil field
- Pipeline
- Terminal
- Refinery

SOURCES: HUMAN RIGHTS WATCH; IHS ENERGY GROUP
IMAGE BY ROBERT STACEY, WORLDSAT INTERNATIONAL INC.

Oil Tracks

Amid twisting waterways, pipeline channels cut paths across the Cawthorne Channel area (right). Spills in the Scotland-size delta, many caused by sabotage, have created one of the world's most polluted regions and threaten Africa's largest remaining mangrove forest. Rebels use the maze of creeks and channels to avoid capture by the military.



The government documented 6,817 spills—practically one a day for 25 years—but analysts suspect the real number may be ten times higher.

Wading through swamp waters discolored by an oil spill, Chief Sunday Ugwu assesses the damage in Odiemerenyi. Companies usually offer compensation, but activists claim that payments are too low and don't reach the affected people.

The meetinghouse had no electricity, but a battery-powered wall clock, the only decoration, showed that another day was ebbing away. Forced to give up fishing, the young men of the village put their hope in landing a job with the oil industry. But offers are scarce. "People from the outside get all the jobs," Harry said, alluding to members of Nigeria's majority ethnic groups—the Igbo, Yoruba, Hausa, and Fulani—who are the country's political and economic elite. "We have diploma holders, but they have nothing to do."

Grievances crowded the dim room. Bernard Cosmos, a strapping young man in a striped polo shirt, spoke out: "I have a degree in petrochemical engineering from Rivers State University in Port Harcourt. I've applied many times with the oil companies for a good job. It's always no. They tell me that I can work in an oil field as an unskilled laborer but not as an engineer. I have no money to get other training."

Isaac Asume Osuoka, director of Social Action, Nigeria, believes that callousness toward the people of the delta stems from their economic irrelevance. "With all the oil money coming in, the state doesn't need taxes from people. Rather than being a resource for the state, the people are impediments. There is no incentive anymore for the government to build schools or hospitals.

"I can say this," Osuoka said firmly. "Nigeria was a much better place without oil."

Such a stark indictment would surely draw reaction from the government and oil companies. But repeated efforts to arrange on-the-record interviews with officialdom—oil company executives, the governor of Rivers state, the commander of the Joint Task Force, which is the military arm responsible for security in the delta—were foiled. Shell and Total, a French company, had offered tours of their facilities, but soon after I arrived in the delta, a spate of kidnappings of foreign oil workers, especially around Port Harcourt, prompted the multinationals to restrict the movements of personnel.





Amid the violence, the oil companies have hunkered down in silence.

At the Finima meetinghouse, the men grew restless and, one by one, drifted into the dusk. Before he left, Felix Harry declared that faith in God would reward the community. That belief must be deep on Bonny Island, judging from the barrage of signs for revival meetings and church services along island roads. One church promoted PUSH: Pray Until Something Happens. Christianity has found fertile ground in the delta after Protestant missionaries arrived in force in the mid-1800s, and it is now the dominant faith.

Harry recited Psalm 91, praising God with

a flourish: “He is my refuge and my fortress.” We walked outside. There, stranded on the shore, were the village fishing boats, several dozen of them. Only a miracle would get them into the water.

Across the delta, people are hoping that someone will pay attention to the region’s problems and intervene. The U.S. and western Europe, the major consumers of Nigerian oil, are watching closely. With the U.S. consulate in Lagos warning of a possible rebel attack on Bonny Island, diplomats are urging greater military security. Stockholders of the oil companies are asking *(Continued on page 108)*





Toxic smoke from tire fires—used to loosen the skin of animals—billows around a worker carrying a goat to a butchering table at the Trans-Amadi abattoir in Port Harcourt. Meat substitutes for fish in the delta diet as pollution causes catches to decline.



A scolding remark chalked on a desk reflects the grim condition of a school in Ogunlaga. Teachers often don't show up, and pupils are scarce. Though delta states receive millions of dollars a month in oil revenue, little of it reaches rural communities.



“The companies didn’t consult with villagers. They handed out cash to chiefs. It wasn’t effective at all.”

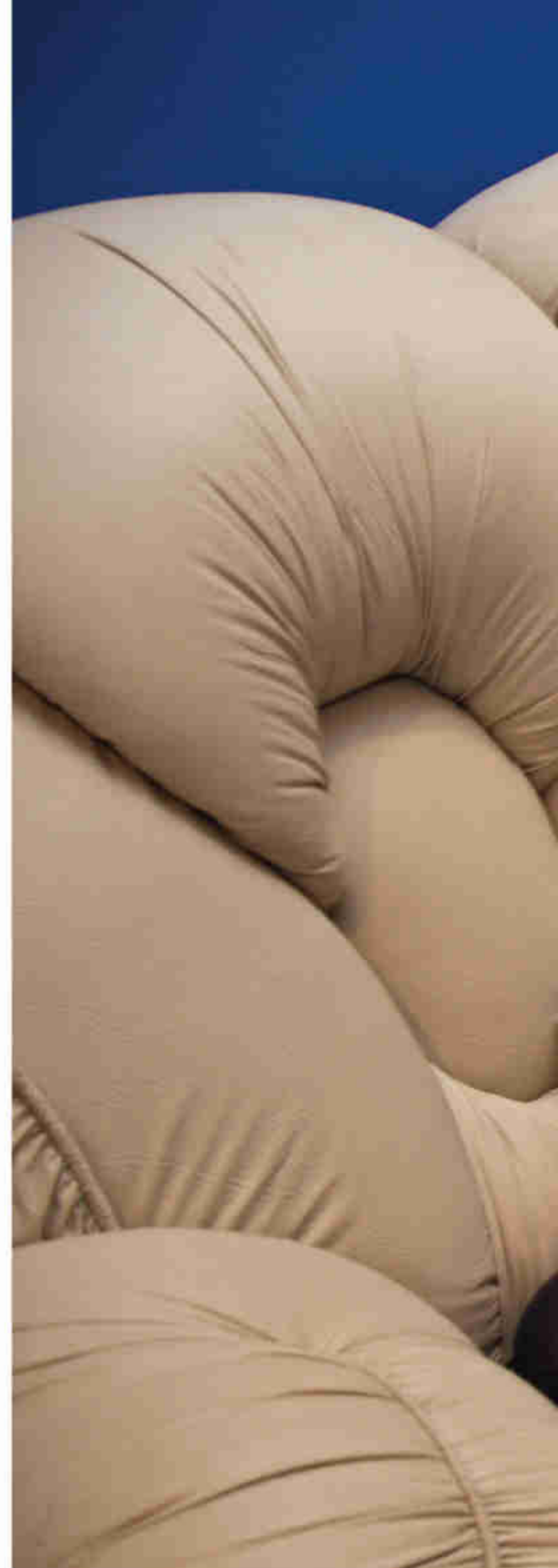
MICHAEL WATTS, AFRICA SCHOLAR

Kingdom Elenwa, traditional ruler of the Egi people, relaxes with his grandson after the annual yam festival in Akabuka. The oil firm Total paid for the furniture.

why the situation has turned so perilous. Who is to blame? The answers are as complicated and murky as the water trails in the delta.

When the oil curse began with that first great gusher in the creekside village of Oloibiri, 50 miles west of Port Harcourt, Nigeria was still a British colony. At independence in 1960, few observers expected that Nigeria would mature into an oil giant. But in subsequent decades, the oil companies, led by five multinational firms—Royal Dutch Shell, Total, Italy’s Agip, and ExxonMobil and Chevron from the U.S.—transformed a remote, nearly inaccessible wetland into industrial wilderness. The imprint: 4,500 miles of pipelines, 159 oil fields, and 275 flow stations, their gas flares visible day and night from miles away.

No one can deny the sheer technological achievement of building an infrastructure to extract oil from a waterlogged equatorial forest. Intense swampy heat, nearly impenetrable mangrove thickets, swarming insects, and torrential downpours bedevil operations to this day. But mastering the physical environment has proved almost simple compared with dealing with the social and cultural landscape. The oil firms entered a region splintered by ethnic rivalries. More than two dozen ethnic groups inhabit the delta, among them the Ijaw, the largest group, and the Igbo, Itsekiri, Ogoni, Isoko, and Urhobo.



These groups have a history of fighting over the spoils of the delta, from slaves to palm oil—and now, crude oil. The companies disturbed a fragile landscape that supported fishing and farming. Engineers and project managers constructing pipelines through a mangrove swamp, or laying roads through marshland, could disrupt spawning grounds or change the course of a stream, threatening a village’s livelihood.

Recent reports by the United Nations Development Program and the International Crisis Group identify some of the questionable strategies employed by oil companies: paying off village chiefs for drilling rights; building a road or dredging a canal without an adequate



environmental impact study; tying up compensation cases—for resource damages or land purchases—for years in court; dispatching security forces to violently break up protests; patching up oil leaks without cleaning up sites.

“After 50 years, the oil companies are still searching for a way to operate successfully with communities,” says Antony Goldman, a London-based risk consultant. The delta is littered with failed projects started by oil companies and government agencies—water tanks without operating pumps, clinics with no medicine, schools with no teachers or books, fishponds with no fish.

“The companies didn’t consult with villagers,”

says Michael Watts, director of the African Studies Program at the University of California, Berkeley. “They basically handed out cash to chiefs. It wasn’t effective at all.”

Last summer, skittish oil prices hit \$78 a barrel, partly because of an attack on a Shell flow station. The high prices more than offset production losses caused by the growing instability, helping earn Shell and the other multinationals record profits in 2006. Meanwhile, more oil fields continue to open, many of them offshore where the infrastructure, though far more expensive than on land, is much safer from sabotage and theft. The deepwater fields are attracting aggressive new investors as well.

China, India, and South Korea, all energy-hungry, have begun buying stakes in Nigeria's offshore blocks. "Most Western companies in Nigeria will find it difficult to compete, especially with China," Goldman says. That's because oil purchases by the Chinese come with their commitment to finance large infrastructure projects, such as rehabilitating a railroad line.

The largest new petroleum endeavor on the delta is taking shape along the Nun River, a tributary of the Niger. Operated by Shell, the Gbaran Integrated Oil and Gas Project, scheduled to begin producing in 2008, will encompass 15 new oil and gas fields, more than 200 miles of pipeline, and a sizable gas-gathering plant. New roads are already gashing the forest. Mounds of long black pipes await burial. Near a bank of the Nun, Nigerian soldiers crouch behind a ring of sandbags, a .60-caliber machine gun facing the road as they guard the entrance to the construction site of the gas plant. Cranes and bulldozers crawl over a cleared space large enough to fit two shopping malls. From the air, it must look as if a patch of skin has been removed from the face of the forest.

Activists with human rights groups are pressuring Shell to learn from past mistakes and treat this high-profile project, which affects 90 villages, as a chance to work better with communities. Michael Watts is advising NGOs on how to educate the local people about their rights. "For Shell to conduct business as usual would be a public relations disaster," Watts says. "Folks say, 'Look, these oil companies are making billions by taking out this black stuff from our territory—they should have some ethical and social responsibilities.'"

A cautionary tale unfolds at Oloibiri, where a wellhead, or "Christmas tree," stands in an overgrown plot. Nothing has flowed from it for years. A weathered sign states the facts: "Oloibiri Well No. 1. Drilled June, 1956. Depth: 12,000 feet." Nearby, a plaque dating from 2001 commemorates a presidential visit and the laying of a foundation stone for the Oloibiri Oil and Gas Research Institute, a projected government-funded museum and library. The stone is still there, but nothing else. A few local youths guard the site, not so much to protect it as to demand money from anyone who wants to snap a picture.

In the town of Oloibiri, whose population has dropped from 10,000 to fewer than 1,000

in the past 30 years, a dirt road passes between rough-hewn houses, some roofed with thatch, others with sheets of corroding metal. A small shop offers a few bananas and yams. Inside the only freshly painted structure, a lemon yellow, two-story house, Chief Osobere Inengite of the Ijaw tribe apologizes for the appearance of his town: "Oloibiri is supposed to be compared to Texas," he said. "I ask you, in Texas have the people in 50 years seen one second of darkness? But look here, we have no light, no water, no food, no jobs."

The chief looked prosperous. He was wearing an ornate black-and-purple robe, a chunky coral necklace, and a black derby, his outfit for a neighboring chief's coronation downriver in Nembe later that day. Like most chiefs, Inengite has a business—dredging sand from the river for roadbuilding. He always keeps an eye out for visitors to Nigeria's historic Well No. 1. He wants them to leave Oloibiri with a message for Shell, which owns the local oil fields. "Tell them to help us. Tell them to train 50 boys and girls from here for jobs," the chief pleaded. Then he sighed, "If we had never seen oil, we would have been better off."

Where does all the oil money go? That question is asked in every village, town, and city in the Niger Delta. The blame spreads, moving from the oil companies to a bigger, more elusive, target: the Nigerian government. Ever since it nationalized the oil industry in 1971, the government has controlled the energy purse. In a joint venture arrangement, the state, in the name of the Nigerian National Petroleum Corporation, owns 55 to 60 percent of multinational oil operations onshore. The windfall in revenues from this arrangement has grown in real dollars from 250 million a year to more than 60 billion in 2005. During that time, even though the government has evolved from a military dictatorship to a democracy (the latest attempt at civil governance began in 1999), what has not changed is what an International Crisis Group report calls a "cancer of corruption." A Western diplomat quoted in the report was even more direct, referring to "the institutionalized looting of national wealth." The money involved is staggering. The head of Nigeria's anticorruption agency estimated that in 2003, 70 percent of oil revenues, more

China, India, and South Korea have begun buying stakes in offshore blocks.

than 14 billion dollars, was stolen or wasted.

On paper, a mechanism does exist for distributing oil revenues somewhat fairly. The federal government retains roughly half and gives out the rest each month, on a sliding scale, to the 36 state governments. The core oil producers—Rivers, Delta, Bayelsa, and Akwa Ibom—receive the most. During the month I was in the delta, those four states divided up more than 650 million dollars.

But there is no discernible trickle down.

Newspaper articles and court cases document spectacular misuses of the money by military men and public office holders—such as the now imprisoned former Bayelsa governor Diepreye Alamieyeseigha—who stash hundreds of millions of dollars in foreign bank accounts to buy mansions in the U.S. and send their children to private schools in London. For the delta's 30 million people—most of whom struggle on less than a dollar a day—seeing this kind of money coming into their states with essentially none of it reaching them has created conditions for insurrection.

Nigeria's oil money won't keep coming, of course—perhaps another 40 years, the experts say. Natural gas is a fallback. Nigeria's reserves are estimated at 184 trillion cubic feet, good for an estimated 240 years of production at current levels. In the meantime, Antony Goldman says, "The government is following a simple plan for oil extraction: We've got to get what we can now, now."

Isaac Osuoka remembers the first time he saw frozen fish. It was the late 1970s, and he was five. A peddler caused a stir as he entered Osuoka's delta town of Oeliabi (now Akinima) with a carton of what he called ice fish. "We never had fish brought in from outside," said Osuoka, who now lives in Port Harcourt. "We had no idea what frozen fish meant. There were rumors that this fish was kept in a mortuary."

Frozen fish was a harbinger of the changes that would traumatize Osuoka's community. "As a boy, I could stroll to the rivers or back swamps with a rod and a net and come back with enough fish to feed my family," he recalled. "There was usually enough left over to sell, providing income for us to go to school." This bounty would not survive the coming of oil. Leaks from pipelines and wells, and the building of roads and canals, have disrupted the wetlands. "The

degree and rate of degradation," the UN report warns, "are pushing the delta towards ecological disaster."

In 1996, Osuoka joined Environmental Rights Action, an advocacy group that helps communities defend their resources and learn their legal rights so they can avoid Oeliabi's fate. "We're seeing that environmental damages often happen silently, with their effects not coming out until years later," Osuoka said. "Today, there is not a single person in my community you could describe as a fisherman. We depend almost totally on frozen fish." At market stalls, a piece of frozen croaker or mackerel, most of it imported, goes for almost a dollar, unaffordable for most villagers.

The best environmental studies of the delta were done at least 30 years ago, according to Jimmy Adegoke, a Nigerian-born research scientist at the University of Missouri. To help fill the void, he and a team of researchers conducted fieldwork and a satellite-based study of the delta. They found that between 1986 and 2003, more than 50,000 acres of mangroves disappeared from the coast, largely because of land clearing and canal dredging for oil and gas exploration. "That is a significant amount given how valuable the mangrove ecosystem is," Adegoke said, referring to the coastal forest's high productivity for fish populations. "I think the loss of one acre is too much. You're wiping out the means for people to sustain themselves."

Oil companies operated in the delta for years with little environmental oversight. There was no federal environmental protection agency until 1988, and environmental impact assessments weren't mandated until 1992. What pressure the government exerts now is directed mostly at halting gas flares. Delta oil fields contain large amounts of natural gas that companies have



traditionally elected to burn off rather than store or reinject into the ground, more costly measures. Hundreds of flares have burned nonstop for decades, releasing greenhouse gases and causing acid rain. Communities complain of corroded roofs, crop failures, and respiratory diseases. After first ordering companies to eliminate flaring by 1984, the government keeps pushing back the deadline. Shell, the main offender, recently announced that despite making considerable progress, it could not meet the latest target date of 2008.

On land, there are oil spills, polluting groundwater and ruining cropland. The government documented 6,817 spills between 1976 and

2001—practically one a day for 25 years—but analysts suspect that the real number may be ten times higher. Old, improperly maintained equipment causes many of the leaks, but oil operators blame sabotage and theft, speculating that disaffected community members deliberately cause oil spills to collect compensation money.

Well 13 in Shell's Yorla field had been leaking for five days when I got there. Members of the nearby Ogoni village of Kpean had assembled around a five-foot-high wellhead that stood in the midst of high grass. Puffs of smoke drifted from the iron structure. Oil dripped from its sides into a spreading lake.

"We're expecting Shell, but no one has come



yet,” a villager said. “Soon the oil will leak into the creek over there and spoil our drinking water.”

Shell and Ogoniland share a tragic history. Nigeria’s first mass protest against the oil industry emerged in these tribal lands southeast of Port Harcourt. In 1990, the charismatic writer Ken Saro-Wiwa, outraged by oil spills in Ogoniland, founded the Movement for the Survival of Ogoni People. The organization demanded control of the oil on Ogoni lands and an end to environmental damage. A quarter of a million Ogoni, nearly half the population, rallied in early 1993 to support the cause. Later that year, Shell, citing security concerns, halted production from its 96 wells in Ogoniland—though oil

“Violence begets violence. When someone loses hope, he is devastated, and he will say, ‘Either I fight, or I leave this world.’”

A NIGERIAN UNIVERSITY LECTURER

Mourners in Oporoza take a last look at a MEND rebel killed by the Nigerian military. Insurgents later struck back, attacking oil facilities and kidnapping dozens of workers.

from wells outside the area continued to flow in pipelines through Ogoni territory.

Alarmed by Saro-Wiwa’s popular support, Nigeria’s military government brought charges of murder against him and fellow activists. The government accused them of instigating the mob killings of four Ogoni leaders from a rival faction. At a tribunal widely regarded as a sham, and with the alleged complicity of Shell, Saro-Wiwa and eight others were found guilty and hanged in 1995. Though the world community reacted with outrage, and Saro-Wiwa’s son initiated a lawsuit against Shell for human rights abuses (which is ongoing), the situation has not improved. In fact, Isaac Osuoka told me, “things have gotten worse since Ken was murdered.”

To this day, safety concerns and lengthy, often hostile negotiations with community leaders over access fees and compensation payments hamper Shell’s response to spills. When I heard that the leak at Well 13 had become a fire, I returned to Kpean. Black smoke was flooding the sky above the palm trees. This time I couldn’t get close to the well—a group of angry Ogoni youths blocked my vehicle.

“Get out, white man! You work for Shell!” one yelled.

“You want to see it? Give us 100,000 naira,” another shouted. He was demanding \$800.

A few days later, I asked Patrick Naagbantou,





Oil leaves its mark in Okrika, from a company umbrella to a trail of pipelines coiling through town. Since oil started flowing, most communities have seen living standards fall, betraying the hope that oil once brought to Nigeria.

an Ogoni journalist who had marched with Saro-Wiwa, to convince the village chief to let us in. Naagbanton led the way, shoving through the crowd toward the well. A fireball was erupting from the ground. The flames roared. Within the inferno, the iron Christmas tree was melting like an effigy thrown on a funeral pyre. Letam Nwinek, one of the villagers, pulled us away from the heat. "We're afraid that if the fire enters the pipeline, the whole community could go up," he said. "Shell keeps promising to come, but they say they need more foam and special equipment because the fire has grown so large."

Suddenly, the crowd began scattering. A man dressed for the city in a pink shirt and black beret came up to us.

"You'd better leave. *Now!*"

Our evictor, Marvin Yobana, was president of the Ogoni Youth Council. As he spoke, five men surrounded us in a threatening stance.

"Yobana is what passes as an Ogoni leader today," Naagbanton said as we retreated. "He's a thug. I believe he's negotiating with Shell to gain a lucrative clean-up contract and doesn't want journalists around." Taking a last look at the fire, Naagbanton said with disgust, "He's just part of the predatory, parasitic struggle to get oil money."

Well 13 would burn for two more months before a Shell team arrived to extinguish it.

“Is anyone listening?" Ken Saro-Wiwa had asked in his final newspaper column. "The delta people must be allowed to join in the lucrative sale of crude oil," he wrote. "Only in this way can the cataclysm that is building up in the delta be avoided."

The cataclysm is upon the delta. As I write this, 70 militants have just attacked a Shell convoy in the Cawthorne Channel, taking 25 oil workers hostage. Rebels have killed nine Nigerian soldiers in a firefight near Brass Island, the site of a large, vulnerable export terminal. Meanwhile, east of Port Harcourt, gunmen have raided an ExxonMobil residential compound and abducted four Scottish oil workers, demanding ten million dollars each for their release.

The number and severity of attacks in the delta have been building, led by youth groups

demanding access to the oil wealth in their territories. This surge in militancy is emblematic of a continent-wide frustration among the young, says Michael Watts, of the University of California. "Across Africa you have a huge number of alienated youths, politically footloose, who thought they could achieve something with their countries' moves to independence and democracy. Those hopes have been almost everywhere violently snuffed out. The youth are pissed off and willing to up the ante."

In the Niger Delta, escalating violence has undermined the country's financial stability and its ability to supply crude to the Western world. Shipments from new offshore rigs are making up for some of the oil lost to sabotage, but rebels identified with MEND have threatened to shut down everything. The day the U.S. consulate warned of the possible attack on Bonny Island, a spokesman for MEND boasted to the press: "We will wipe out the Nigerian oil export industry in one swipe."

Late one night in a darkened neighborhood in central Port Harcourt (the city was experiencing one of its regular blackouts), an angry young man, who asked for anonymity, explained his outrage. "Nigeria made its greatest mistake taking the life of that man Ken Saro-Wiwa. It will not be forgiven. When the Nigerian state overreacted like that, the thinking became, We have to carry weapons unless we want to die. Violence begets violence. When someone loses hope, he is devastated, and he will say, 'Either I fight, or I leave this world.'"

This young Nigerian is a university lecturer, who says the time for talking has passed. "When the situation in the delta threatens to turn into another Middle East, then the world will finally intervene."

Another night in Port Harcourt, a prolonged gun battle erupted outside my compound. Volleys from AK-47s, answered by the booms of pump-action shotguns, sent me running to barricade my door. The gunmen abducted four expatriates from Goodfellas, a nightclub nearby. (It was this incident that led the oil companies to cancel their tours.) A Dutch oil worker on contract to Shell, who makes \$80,000 a year as a pipeline construction supervisor, told me he has to travel everywhere with an armed escort. "You must keep it in your mind that people out there may kill you," he said.

➤ **Blood and Oil** Hear voices from the Niger Delta, where oil means poverty and suffering for many. See this multimedia production at ngm.com/0702.

With every assault by the insurgents, the Nigerian military seems to answer with devastation. One evening, a gang of kidnappers dressed in army camouflage came by boat to a waterside neighborhood called Aker Base on the outskirts of Port Harcourt, stormed into a bar, and snatched an Italian construction worker employed by Saipem, an oil-servicing company. During the grab, the assailants killed a soldier. Within hours, troops swept into the shantytown and burned down every structure except a bank. Days later, stunned residents wandered through the charred ruins like ghosts; some 3,000 had lost their homes.

A woman clutching her melted cell phone moaned, "I have to tell my mother, my brothers and sisters what happened. I don't know where to start and where to end." In front of a collapsed church, the village chief implored a crowd to "Let God fight this case." A lawyer hired by the village provided little comfort when he said that Saipem would meet with the community "maybe in a week" and ask for a list of everything lost.

"I blame the government," said Caroline Mathias, the owner of the bar, staring at a pile of melted bottles and the crumpled metal roof where her business had stood. "The government should help us. I'm begging them. We are not the ones who killed that soldier."

The Italian worker was freed five days after the sack of Aker Base. That month, 18 foreigners were abducted; all were released, reportedly after hefty ransom payments.

No one is sure how many delta people have picked up the gun to fight for their rights. Estimates range from the low hundreds to the low thousands. What is certain is that each time the military reacts with extreme measures, the number rises.

The rebels seem unafraid, as when a hundred or so MEND members and supporters gathered openly at a morgue in the city of Warri for the funeral service of nine militants killed on the water in an ambush by the Nigerian military. Afterward, MEND leaders invited the press to accompany boats taking the caskets to villages for burial. Along the way, men waved guns from jetties, and white flags flew from huts. The men wore conspicuous red-and-white ties knotted around their arms. The ties and flags were symbols of Egbesu, the Ijaw god of war. Warriors wear the knots as protection

"Everyone was sure they would be blessed with the coming of the black gold. But we have nothing. I feel cheated."

PATRICK AMAOPUSANIBO, RETIRED BUSINESSMAN

against death, believing that having taken an oath to Egbesu, nothing metal—neither bullet nor machete—can harm them. Farther on, a rebel camp sat brazenly on a riverbank, the blue roofs of its barracks plainly visible to oil company helicopters.

No solution seems in sight for the Niger Delta. The oil companies are keeping their heads down, desperate to safeguard their employees and the flow of oil. The military, ordered to meet force with force, have stepped up patrols in cities and on waterways. The militants are intensifying a deadly guerrilla offensive, hoping that rising casualties and oil prices will force the government to negotiate. National elections in April could exacerbate the violence, especially if politicians resort to the practice of hiring youth gangs to deliver votes at gunpoint.

Optimism is as scarce as blue sky in the sodden delta. "Everyone was sure they would be blessed with the coming of the black gold and live as well as people in other parts of the world," said Patrick Amaopusanibo, a retired businessman who now farms near the village of Oloama. He had to speak loudly to compete with the "black noise," the hissing and roaring of a gas flare near his cassava field. "But we have nothing. I feel cheated."

In some parts of the Niger Delta, oil still looks like a miracle. In the run-down fishing village of Oweikorogba on the Nun River, where families of ten sleep in a single room under leaky thatch roofs, hope materialized a year ago in the form of Chinese prospectors. They left without finding oil, but the people of Oweikorogba want them back, confident that they'll find a pot of gold. And if a stranger warns these villagers that oil is a curse in Nigeria, they will look at him and say: "We want oil here. It will make everything better." □

Hawaii's unearthy worms



Corkscrew gills and grooved feeding tentacles splay from a spaghetti worm, one of the many thousands of worm species that live at sea. This reef dweller protects its six-inch body in a sand-and-mucus tube while its appendages drift, snagging detritus and distracting foes.

THELEPUS SETOSUS, UP TO 1 FOOT, TENTACLES UP TO 3 FEET LONG

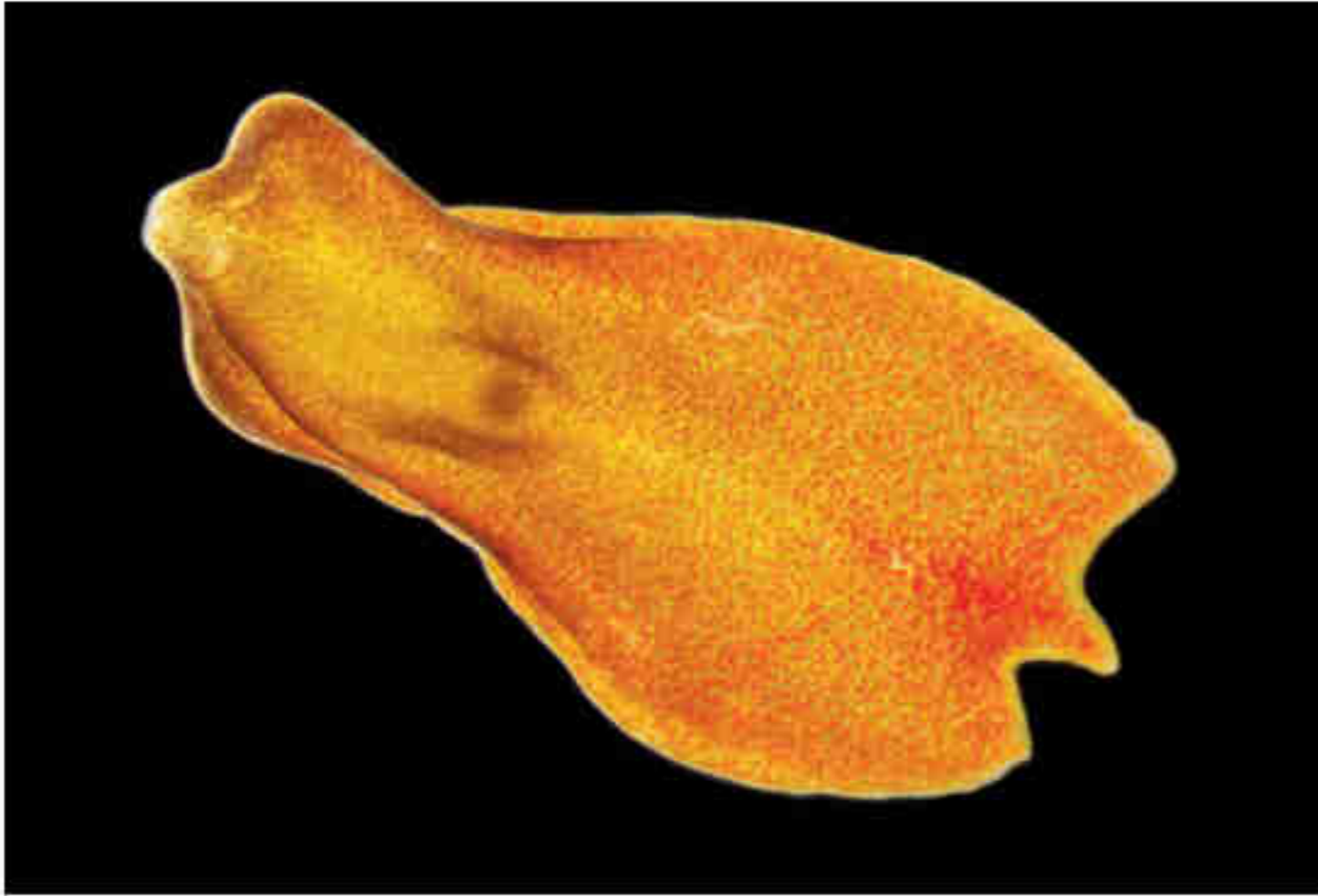






Spawning on a summer night, fire worms emit clouds of eggs and sperm at high tide—a performance triggered by the full moon. Harpoon-like bristles filled with a neurotoxin protect the worms, which inhabit shallow reefs and feed on crustaceans and anemones. Hawaiians call the worm *'aha huluhulu*, “hairy cord.”

PHERCARDIA STRIATA, 3-10 INCHES



Photographs by Darlyne A. Murawski

Gardeners can keep their earthworms. They are worthy but uncool cousins of the marvelously diverse worms that live in the sea, creatures that do work as vital as their dirt-tunneling kin—filtering and feeding an ecosystem—but with otherworldly elegance.

Pick your ocean: It's got worms in it. They are, in fact, one of the most common marine animals, a ready meal for many of the fish we eat. Rocky and sandy shores worldwide are rife with worms, but species also float in the open water and inhabit the floor of the deep sea. Some are pinhead-size, while certain ribbon worms stretch nearly 200 feet—the longest animals on Earth. Some filter-feed, some stalk their prey, some eat their kin, and they have evolved at least 18 different ways to reproduce, including by breaking into pieces. An especially grand assortment occurs in shallow waters off the Hawaiian Islands, including these, photographed at sea and in the lab.

The spiny ancestors of today's marine worms were among the first sea animals more than 500 million years ago. Scientists can only guess at the number of species—estimates range from 25,000 to millions. In the 18th century the pioneering naturalist Carolus Linnaeus dumped all pliable, legless invertebrates into a single category, Vermes, but since then scientists have divided worms among various branches of life's family tree. Many of the marine worms belong to the annelids, a sundry bunch of segmented, mostly bristled animals that slide between rocks or poke from tubes. Though rarely seen, Vermes, in all their extravagant forms, have found success at sea—and help make the sea a success. —*Jennifer S. Holland* NATIONAL GEOGRAPHIC STAFF



👉 **A Worm's World** Peer into the lives of marine worms in a multimedia presentation at ngm.com/0702.



The flat and the lean: An acoel (opposite), a tiny flatworm without a gut, inhabits stony shallows. Photosynthetic algae in its skin help nourish it. More complex, an acorn worm (above) uses its smooth proboscis to nose through sand, sieving nutrients from the sediments. It has a liver (the nubs along its body) and gill slits like those of sharks—and embryonic humans. Its noxious skin puts off predators, and its head (collared section) can regenerate in days if severed.


OPPOSITE: *CONVOLUTRILOBA LONGIFISSURA*, 0.08-0.12 IN; ABOVE: *PTYCHODERA FLAVA*, UP TO 15 IN;
PROJECT CONSULTANT: AMY MAXMEN, KEWALO MARINE LABORATORY, HONOLULU



Tidying the sea, feather duster worms wave plankton-catching tentacles above a coral head covered with stringy anemones and soft corals (green). A nibbling fish or even a passing shadow triggers a duster's giant nerve fibers to retract the feathers with lightning speed. They slowly unfurl again once the danger is gone. The worms' leathery hideaway tubes are secretions of mucus-coated silt; pulled from its tube (left), a worm's body uncurls to about four inches.

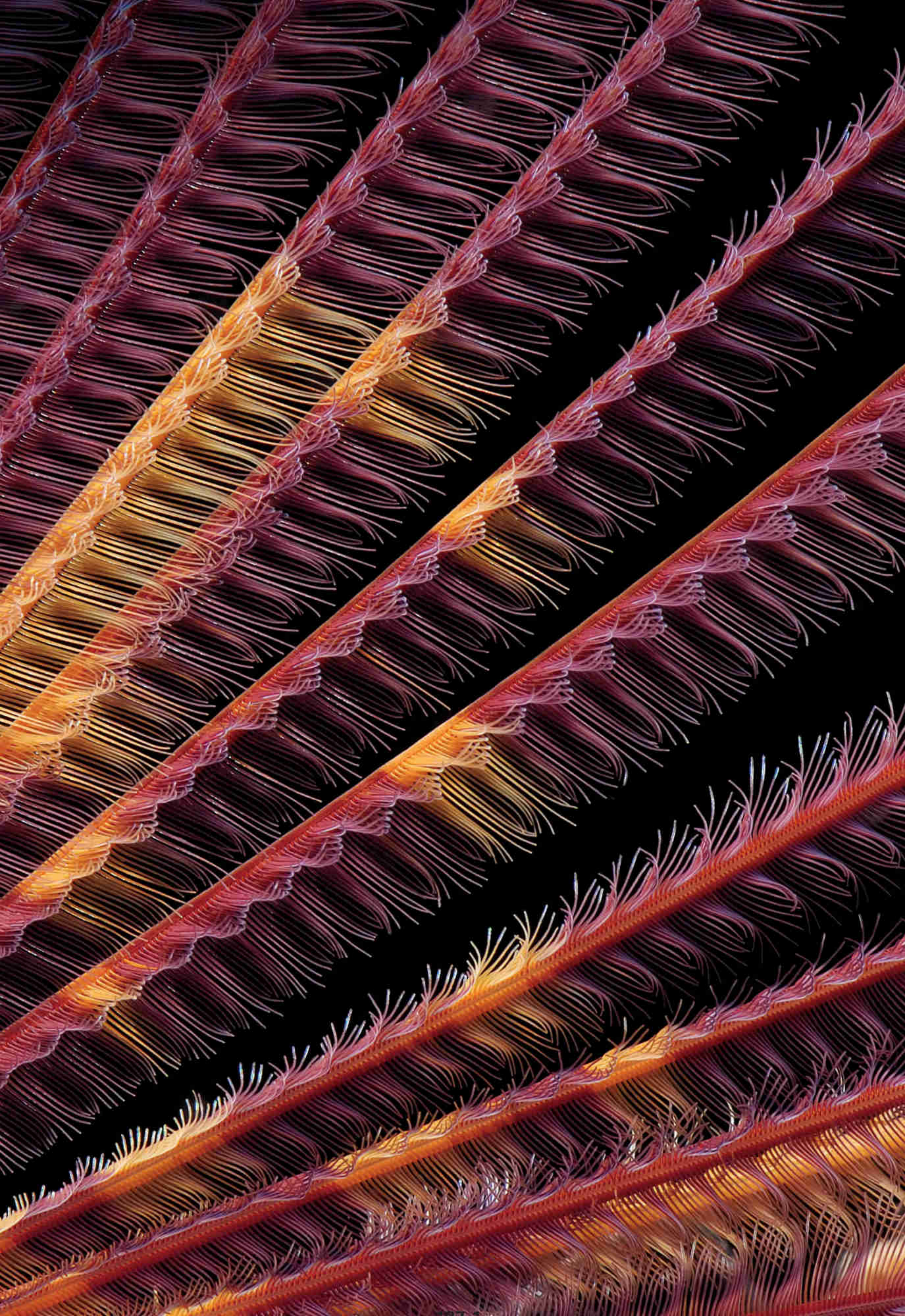
SABELLASTARTE SPECTABILIS, TENTACLES UP TO 4.5 IN LONG



A detailed close-up photograph of the tentacles of a feather duster worm, Sabellastera spectabilis. The tentacles are arranged in a fan-like pattern, each consisting of a central stalk and a wide, flat, ruffled edge. The ruffles are composed of numerous fine, parallel hairs that create a mesh-like structure. The color of the tentacles is a vibrant, iridescent purple and blue, with some areas appearing more yellowish or orange due to the lighting. The background is dark, making the tentacles stand out prominently.

A net of fine hairs, shown in a close-up of a feather duster worm's tentacles, sweeps particle-laden water to grooved tracks, which carry the particles—including food and silt for building its protective tube—to the animal's mouth. Bright colors may warn would-be predators of toxicity.

TENTACLES OF *SABELLASTERA SPECTABILIS*





Roving feeders, these worms leave their burrows to swim through the shallows with paddle-like appendages (visible on opposite page), hunting and scavenging. Carnivorous worms (top and opposite) use their jaws to nab other worms, shrimps, or even fish much larger than themselves. Jawless worms, like the juvenile above, filter sediments they gather with their long, creeping tentacles. Such polychaetes—meaning many bristles—may be as wispy as a blade of grass or as thick as a garden hose.

(TOP) FAMILY EUNICIDAE, 4 IN; (ABOVE) FAMILY CIRRATULIDAE, 1 IN; (OPPOSITE) *EUNICE AUSTRALIS*, 2.5 IN







A peanut worm, named for its plump trunk, may burrow into mud or rock, squeeze into a coral crevice, or pilfer an empty shell to keep its body safe. Its crown of pink tentacles, which gather detritus for food and absorb oxygen, emerges (above right) from a neck-like extension housing the head and mouth. When the worm is threatened, it hides its head (above left). Peanuts come in some 350 different species, found from the shallows to the ocean depths. Off Hawaii peanut worms can form dense colonies, their ungainly shapes hidden by thousands of tentacles dancing in the current. □

THEMISTE LAGENIFORMIS, 1.5 IN LONG



A photograph showing mangrove trees with their roots extending into the water. The roots are covered in a dense thicket of colorful coral and sea life, including purple and orange corals. The background shows a dense canopy of green mangrove leaves.

Knee-deep in the ocean,
mangroves support abundant
sea life and flourish where no
other trees can survive.

Forests of the

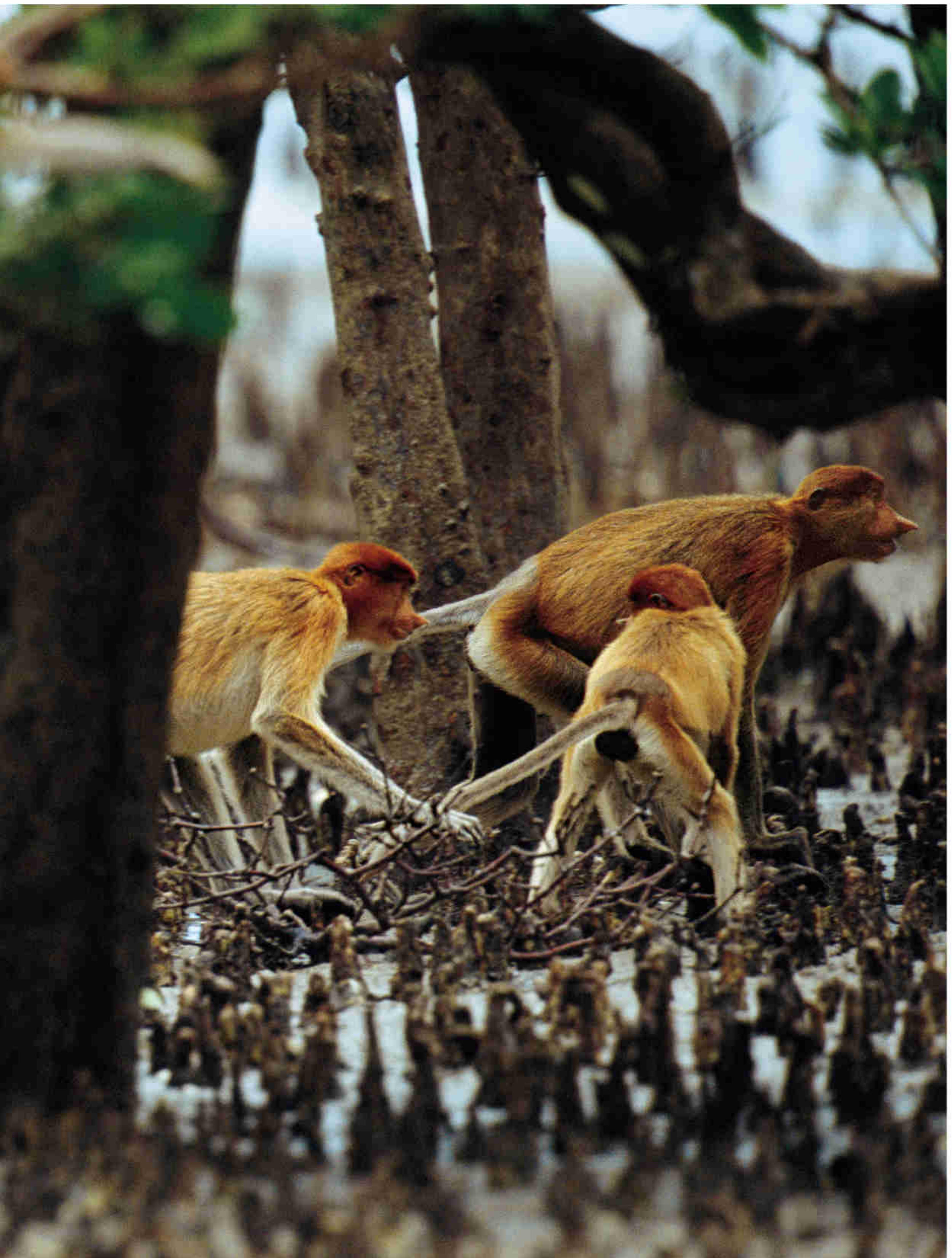


Tide

Underwater view of
a mangrove forest
off the coast of Belize



Proboscis monkeys pick their way through thickets of mangrove roots in Malaysia's Bako National Park. These rare primates—just 8,000 are estimated left in the wild—live only on



the island of Borneo. Around the globe mangrove forests provide crucial habitat for endangered species, from tigers and crocodiles to fragile hummingbirds.

BY KENNEDY WARNE

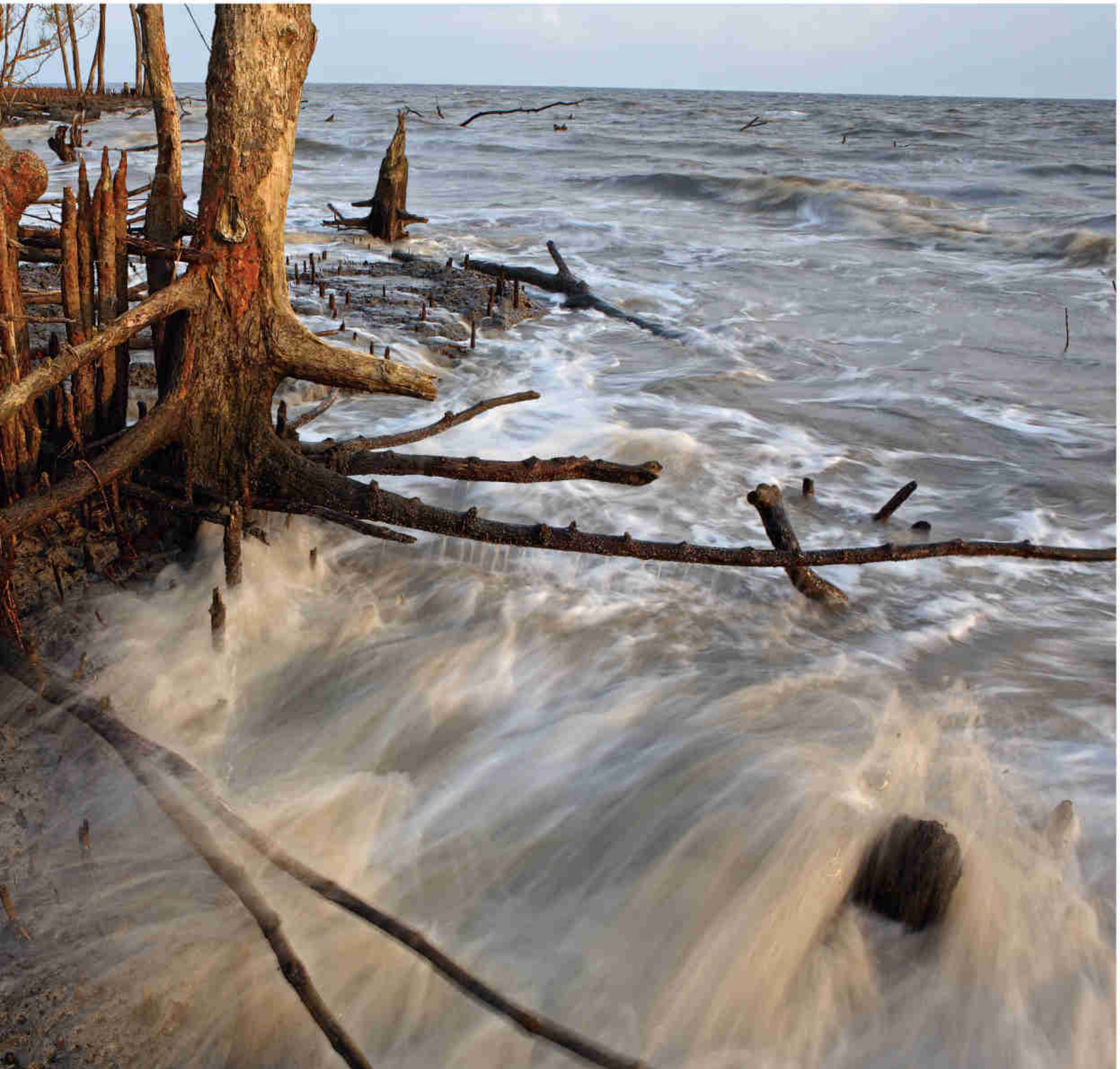
PHOTOGRAPHS BY TIM LAMAN

Mangroves live life on the edge. With one foot on land and one in the sea, these botanical amphibians occupy a zone of desiccating heat, choking mud, and salt levels that would kill an ordinary plant within hours. Yet the forests mangroves form are among the most productive and biologically complex ecosystems on Earth. Birds roost in the canopy, shellfish attach themselves to the roots, and snakes and crocodiles come to hunt. Mangroves provide nursery grounds for fish; a food source for monkeys, deer, tree-climbing crabs, even kangaroos; and a nectar source for bats and honeybees.

As a group, mangroves can't be defined too closely. There are some 70 species from two dozen families—among them palm, hibiscus, holly, plumbago, acanthus, legumes, and myrtle. They range from prostrate shrubs to 200-foot-high timber trees. Though most prolific in Southeast Asia, where they are thought to have originated, mangroves circle the globe. Most live within 30 degrees of the Equator, but a few hardy types have adapted to temperate climates, and one lives as far from the tropical sun as New Zealand. Wherever they live, they share one thing in common: They're brilliant adapters. Each mangrove has an ultrafiltration system to keep much of the salt out and a complex root system that allows it to survive in the intertidal zone. Some have snorkel-like roots called pneumatophores that stick out of the mud to help them take in air; others use prop roots or buttresses to keep their trunks upright in the soft sediments at tide's edge.

These plants are also landbuilders par excellence. Some Aborigines in northern Australia believe one mangrove species resembles their primal ancestor, Giyapara, who walked across the mudflats and brought the tree into existence. The plants' interlocking roots stop river-borne sediments from coursing out to sea, and their trunks and branches serve as a palisade that diminishes the erosive power of waves.





A vast breakwater on the Bay of Bengal, the Sundarbans covers nearly 4,000 square miles of Bangladesh (above) and India, making it the largest mangrove wetland on Earth. Worldwide, these coastal forests thwart wave-driven erosion and capture riverborne sediments as they meet the sea, building new land.



Despite their strategic importance, mangroves are under threat worldwide. They are sacrificed for salt pans, aquaculture ponds, housing developments, roads, port facilities, hotels, golf courses, and farms. And they die from a thousand indirect cuts: oil spills, chemical pollution, sediment overload, and disruption of their sensitive water and salinity balance. Calls for mangrove conservation gained a brief but significant hearing following the 2004 Indian Ocean tsunami. Where mangrove forests were intact, they served as natural breakwaters, dissipating the energy of the waves, mitigating property damage, perhaps saving lives. Post-tsunami, the logic of allowing

a country's mangrove "bioshields" to be bulldozed looked not just flawed but reprehensible.

Bangladesh has not lost sight of that logic, putting a great premium on the ability of mangroves to stabilize shores and trap sediments. A low-lying country with a long, vulnerable coastline, Bangladesh is also land starved, with a crushing population density of 2,500 persons per square mile. By planting mangroves on delta sediments washed down from the Himalaya, it has gained over 300,000 acres of new land on the Bay of Bengal. The plantings are relatively new, but there have been mangroves here for as long as the Ganges, Brahmaputra, and Meghna Rivers have



The forests mangroves form are among the most productive and biologically complex ecosystems on Earth.



Roosting in Trinidad's Caroni Swamp, scarlet ibises (left) are a beloved symbol of the Caribbean nation—and the inspiration behind thousands of acres of mangrove preserves. *Bruguiera gymnorhiza* (above) ring the Micronesian island of Kosrae, their tangled roots home to swarms of mosquitoes and a stew of crab, shrimp, and fish.

been draining into the bay. The vast tidal woodland they form is known as the Sundarbans—literally “beautiful forest.” Today, it's the largest surviving single tract of mangroves in the world.

In the forest's most luxuriant sections a dozen mangrove species, from feathery golpata palms to the towering sundri tree, form labyrinthine stands up to 60 feet tall. Beneath the sundri, the glutinous mud bristles with the tree's breathing roots. Twelve inches high and as thick as deer antlers, they grow so tightly together there's barely room to squeeze a foot between them. In drier areas, groves of semi-deciduous mangroves blaze red in the months before the monsoon.

Spotted deer glide through the filtered shade, stopping abruptly when a troop of macaques shriek an alarm call. Woodpeckers hammer in the high branches, while on the forest floor dry leaves rustle with the scuttling of mud crabs. A butterfly called the Sundarban crow—charcoal with splashes of white—rests on a twig, opening and closing its wings like a prayer book.

Evening falls with the *junk junk junk* sound of nightjars, then all is quiet. Night belongs to the tiger. These forests provide one of the last remaining haunts for the Bengal tiger and its only salt-water habitat. According to local tradition, the tiger's name, *bagh*, must never be uttered. To





Radiating from a single *Sonneratia alba*, thousands of root spikes snorkel up through a tidal mudflat in Malaysia's Bako National Park. Tenaciously intricate both above and below ground, the roots of mangroves hold the plants upright in sodden soil, supply them with air when the tide rises, and in some species even remove salt from seawater.

Throughout the tropical world, mangrove forests are the supermarkets, lumberyards, fuel depots, and pharmacies of the poor.

Speak it is to summon it. So people talk of *mamu*, uncle. Uncle tiger, lord of the Sundarbans.

Half a million Bangladeshis risk *mamu*'s displeasure by coming into the Sundarbans each year to harvest its products. They come as fishermen, woodcutters, palm-frond cutters, cutters of thatching grass, harvesters of wild honey. The workers spend weeks at a time in the forest, living off its bounty as they earn a few taka for their labor. Seafood, fruits, medicines, tea, sugar, even the raw materials for beer and cigarettes are to be found in the Sundarbans larder.

Throughout the tropical world it's the same: Mangrove forests are the supermarkets, lumberyards, fuel depots, and pharmacies of the coastal poor. Yet these forests are being destroyed daily. One of the greatest threats to mangrove survival comes from shrimp farming. At first glance, shrimp might seem the perfect export for a poor country in a hot climate. Rich countries have an insatiable appetite for it (shrimp has overtaken tuna to become America's favorite seafood), and the developing world has the available land and right climate to farm it.

A prime location for shrimp ponds, though, happens to be the shore zone occupied by mangroves, an unhappy conflict of interests that has a predictable outcome: The irresistible force of commerce trumps the all-too-removable mangrove. To compound matters, shrimp farmers typically abandon their ponds after a few crop cycles (to avoid disease outbreaks and declining productivity) and move to new sites, destroying more mangroves as they go.

Mangrove-rich Brazil was slow to stake its claim in the bonanza. By the time shrimp fever hit Brazil's northeastern states, around the turn of the millennium, shrimp-farming pioneers such as Thailand, the Philippines, and Ecuador had been uprooting their mangroves for decades. Today, in the Brazilian port city of Fortaleza

ponds the size of football fields crowd the landscape like rice fields. Paddle wheel aerators froth the water, and workers in kayaks fill feeding trays with fish meal. Even where mangroves have been spared, access to them is often blocked by the shrimp farms.

At the riverside settlement of Porto do Céu—"the gates of paradise"—an electrified fence shuts out villagers from their traditional harvesting grounds. But there is worse. The shrimp ponds have no lining, so salt water has percolated through the sandy soil and contaminated the aquifer beneath. The villagers have been forced to abandon wells that until recently drew sweet fresh water to the surface. The water is no longer sweet; it is *salgada*, saline, undrinkable.

At Curral Velho, a community to the west of Fortaleza, people have been finding a voice to oppose Big Shrimp. Demonstrations have been organized, land deals challenged, a public education center set up. Sister Mary Alice McCabe, an American nun who is helping the community in its struggle, says that one of the difficulties in raising awareness about *carcinicultura*—shrimp farming—is that most Brazilians aren't aware of the environmental damage it causes. "Where does it happen, out at sea?" they ask. "No, no, no," we tell them, "they're digging up your mangroves, they're destroying your coastline."

As serious as the threat from shrimp farming is to the world's remaining mangroves, there looms a potentially more disastrous problem: rising sea levels. Standing as they do at the land's frontiers, mangroves will be the first terrestrial forests to face the encroaching tides.

Loss of mangrove forests could prove catastrophic in ways only now becoming apparent. For more than 25 years Jin Eong Ong, a retired professor of marine and coastal studies in Penang, Malaysia, has been exploring a less obvious mangrove contribution: What role might these forests play in climate change? Ong and his colleagues have been studying the carbon budget of mangroves—the balance sheet that compares all the



Edging the tropics from Baja California to the Great Barrier Reef (map), mangroves are increasingly threatened by coastal development. Satellite images tell the tale: In 1987 shrimp farms were expanding around the Central American Gulf of Fonseca, but many mangrove areas remained intact (below). By 1999 (bottom) shrimp farming had swelled, wiping out mangroves, polluting the environment, and disrupting freshwater supplies.



A prime location for shrimp ponds happens to be the shore zone occupied by mangroves, an unhappy conflict of interests.



Seined from Sundarbans tides (above), juvenile shrimp will be raised to market size in brackish artificial ponds. Malaysia has lost half of its mangrove forests—a million and a half acres—in the past 50 years, much of that to aquaculture operations (right) that feed the increasing global appetite for seafood.



carbon inputs and outputs of the mangrove ecosystem—and they've found that these forests are highly effective carbon sinks. They absorb carbon dioxide, taking carbon out of circulation and reducing the amount of greenhouse gas.

By measuring photosynthesis, sap flow, and other processes in the leaves of the forest canopy, Ong and his team can tell how much carbon is assimilated into mangrove leaves, how much is stored in living trees, and how much eventually makes its way into nearby waterways. The measurements suggest that mangroves may have the highest net productivity of carbon of any natural ecosystem (about a hundred pounds per

acre per day) and that as much as a third of this may be exported in the form of organic compounds to mudflats. Mangroves, it seems, are carbon factories, and their demolition robs the marine environment of a vital element.

Ong's team has also shown that a significant portion of the carbon ends up in forest sediments, remaining sequestered there for thousands of years. Conversion of a mangrove forest to a shrimp pond changes a carbon sink into a carbon source, liberating the accumulated carbon back into the atmosphere—but 50 times faster than it was sequestered.

If mangroves were to become recognized as



carbon-storage assets, that could radically alter the way these forests are valued, says Ong. If carbon trading becomes a reality—that is, if forest-rich, carbon-absorbing countries are able to sell so-called emissions credits to more industrialized, carbon-emitting countries—it could, at the least, provide a stay of execution for mangroves.

But Ong notes that the financial incentives have to be great enough to make forest preservation economically viable. “Take Indonesia, which has the largest total area of mangroves of any country in the world. It can’t afford to save them for nothing,” he says. “But if the Indonesians could trade the carbon-storage

potential of their mangroves as a commodity, that would create a great incentive to stop bulldozing them for shrimp ponds or chipping them for the production of rayon.”

Countries that have squandered their mangroves could also replant them, gaining both a tradable asset and coastline protection. At Ong’s research site small boys stuff their pockets with cigarillo-shaped mangrove seeds, or propagules. The boys will sell them for a few cents. Ong says that throughout Asia there’s a run on propagules, as countries replant their mangrove defenses in the wake of the 2004 tsunami.

(Continued on page 150)





Hundreds of thousands of Bangladeshis—including these laborers transporting wood for charcoal production—depend on the natural riches of the Sundarbans for their livelihoods. Nearly half of Bangladesh’s timber comes from these forests each year, along with a multi-million-dollar harvest of wild honey and plants used for roof thatching, baskets, even medicines.



Sunlight pours through the lens-clear waters that wash a Caribbean mangrove forest, flashing against a swirling school of fish and revealing the blaze of a sea star. By trapping sediments



and contaminants flowing seaward from inland farms and towns, mangrove roots help maintain coastal water quality and shield fragile offshore coral reefs from damage.



To reestablish mangroves on the island of Bali, workers set out some 1,300 saplings an acre; nearly a thousand acres have been planted. Indonesia's forestry minister says that since the deadly 2004 tsunami, his people have come to value the protection coastal forests can provide.

On the east coast of Africa, a very different kind of mangrove experimentation is going on. In Hirgigo, Eritrea, a few miles down the coast from the port of Massawa, two men sit on planks on the hot desert sand. With a knife for a chisel and a rock for a hammer, they knock the bottoms out of empty tomato sauce cans—discards from the Eritrean Navy. Nearby, on the shores of the Red Sea, a group of women push the hollow cans into the soft sediment, forming long alleys on the mudflats. Into each can, the women press mangrove propagules.

This is the planting of the Red Sea, the brain-child of cell biologist, cancer-drug pioneer, and humanitarian Gordon Sato. In the early 1980s, Sato's laboratory at the University of California at San Diego developed Erbitux, a breakthrough drug for colorectal cancer. These

days 79-year-old Sato works to cure a different disease—poverty—attacking the problem not by culturing cells but by cultivating mangroves.

Eritrea was reeling from war and famine when Sato first traveled there in the mid-1980s. Since water is such a scarce resource in this arid country, Sato wondered if he could develop some form of salt water-based agriculture on Eritrea's long coastline, to help provide food for the hungry. Mangroves seemed a logical, if unconventional, choice. They occurred naturally, though patchily, along the Red Sea shore, they flourished in salt water, and camels were known to eat the leaves. If camels ate them, why not feed the foliage to sheep and goats? Grow enough mangroves, Sato reasoned, and you could provide food security for thousands.

So, like a maritime Johnny Appleseed, he began planting—and failed. All the saplings died. Undaunted, Sato looked closely at places on the

Plant a few trees, and you usher in an ecosystem. Build nature a house, and she makes it her home.

Eritrean coast where mangroves were growing naturally, and he noticed they occurred only where fresh water was channeled during the brief rains that fall on this desert coast. Sato reasoned it was not fresh water the trees needed but minerals the water was bringing from inland—specifically nitrogen, phosphorus, and iron, elements in which seawater is deficient.

By conducting a few simple trials, Sato and a small team of helpers from the Eritrean Ministry of Fisheries assessed how much of the three elements mangrove seedlings needed and devised a low-tech method of supplying them. When the propagules are planted, a small piece of iron is buried alongside. So, too, is a small plastic bag with holes punched in it containing a fertilizer rich in nitrogen and phosphorus.

Now, six years on, 700,000 mangroves are growing on the formerly treeless shore of Hirgigo. Sato calls the project Manzanar, after the World War II internment camp in the California desert where, during his teens, he and his family were relocated, along with thousands of other Japanese Americans. It was the memory of older internees there coaxing crops from the arid soil that inspired him all these years later.

At Sato's Manzanar many of the mangrove trees are now well above head height, and the yellow-green coats of ripe propagules are beginning to split open, showing the plump green leaves within. The mangrove mud is sprouting pneumatophores, as if someone had sown a crop of pencils. Barnacles and oysters have started to settle on them, and crab and winkle trails criss-cross the sediment. Plant a few trees, and you usher in an ecosystem. Build nature a house, and she makes it her home.

That home extends its influence out to sea. At the end of a long rock jetty, Ibrahim Mohamed Ibrahim peels off his shirt, winds it around his head, then steps into the water to check his net. He wades chest deep along it, feeling the mesh for fish and turning up a nice barracuda and a jack. He cleans them on the rocks,

plunging them repeatedly, almost reverently, in the water.

Since planting began, Hirgigo's fishermen have started to catch small species such as mullet. Ibrahim put the equation simply: "No mangroves, no mullet." And the little fish that make the mangroves their home attract bigger, predatory fish—the kind that snag in Ibrahim's net and sell for good prices in the Massawa market.

In a pen on the outskirts of the village, a flock of sheep crunches mangrove propagules as if they were apples. Sato is using these animals to fine-tune the livestock-rearing side of the project. He has found that mangrove leaves and propagules, though highly nutritious, are not a complete stock food. Fish meal, which Sato is having made locally from fish processing, seems to provide the missing nutrients.

Outside the pen, donkeys nibble in the dust. The stubble of grass is so miserable and sparse it doesn't provide even the faintest green tinge to the parched earth. The nearby houses are nothing more than dusty improvisations of flattened iron, bits of cloth, and scraps of wood. Sato dreams of seeing a livestock pen beside every house. "In this country, a few goats can be the beginning of an empire," he says. "I want to give everyone this chance." Who would have imagined it: The mangrove, foundation of empires.

The town of Massawa recently celebrated the 15th anniversary of its liberation from Ethiopian forces—a David-and-Goliath struggle (as Eritreans tell it) in which the pride of the Ethiopian Navy was bested by a ragtag band of Eritreans in speedboats. A sign on a café shows a soldier in heroic pose and the slogan "Able to do what can't be done."

Out on the mudflats another old soldier is attempting the impossible: turning the tide of poverty by growing mangroves. The gardeners of Manzanar would be proud. □

▲ **In the Forest** See photographs of these soggy ecosystems in our Photo Gallery at ngm.com/0702.



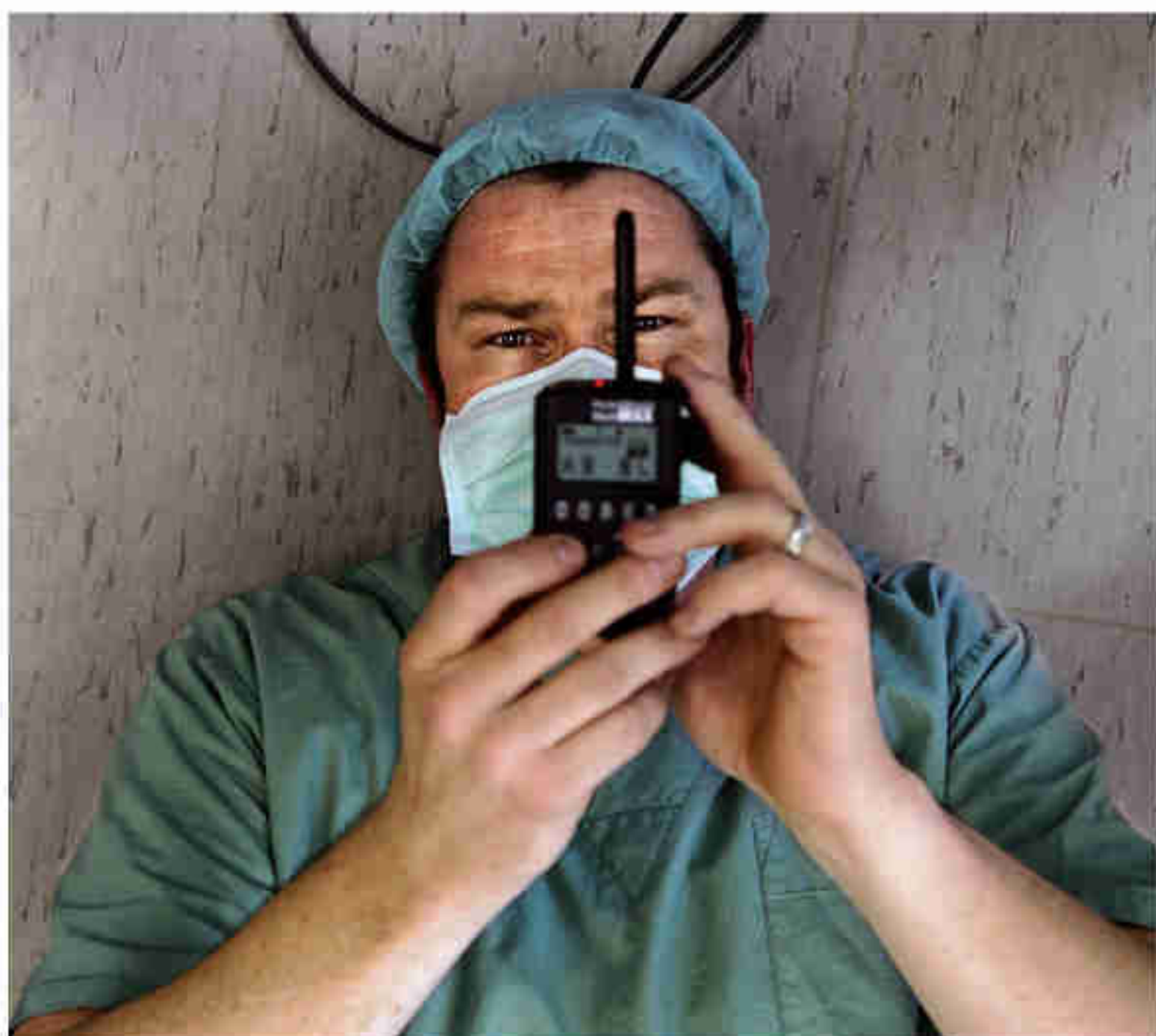
Photographer Ed Kashi and his assistant Elias Courson were photographed hours after their release from custody in Nigeria.

ON ASSIGNMENT **The Perils of Photography**

That things can go wrong is a given on any assignment, but the stakes were unusually high for photographer Ed Kashi, at left, and his assistant Elias Courson while in Nigeria covering “Curse of the Black Gold” in this issue. Government soldiers detained the two for photographing an oil facility without permission. (“There’s no law forbidding it, but it’s generally understood you aren’t supposed to,” Kashi says.) During three days in a locked room at the oil facility, they were repeatedly interrogated by the State Security Service. “This is death,” Courson whispered to Kashi on the fourth day while in a car with three guards. Then one of the officers received a call and ordered the car to turn around. Officials had responded to pleas from Kashi’s wife, NATIONAL GEOGRAPHIC, and Nigerian human rights groups; the men were freed. The ordeal strengthened Kashi’s resolve. Nigeria, he says, “is a place of shadows. No matter how much light you shed on these shadows, there are always others.”

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Robert Clark uses a remote to snap a self-portrait from a camera mounted above the heart surgeon's operating table.

ON ASSIGNMENT **The Heart Beat**

For "Mending Broken Hearts," photographer Robert Clark worked with surgeon Roland Hetzer to shoot the implantation of an artificial heart. Clark mounted a camera above the operating table and rigged its shutter to a remote control device on his computer. Then he fired off a photo every minute or so during the four-hour procedure (see his pictures on pages 60-63). As Clark worked, though, something was tugging at his own heart. That same day, doctors in Kansas were replacing his father's pacemaker. Fortunately, his dad is doing well—and so is Clark. After finishing this story, he took up running, went on a diet, and lost ten pounds.

➤ **Heart Gallery** See Clark's time-lapse photography of the operation at ngm.com/0702.

February Contributors

VOICES: FRANCIS COLLINS, page 32

John Horgan is the director of the Center for Science Writings at Stevens Institute of Technology in New Jersey. He also writes a science blog called Horganism.

MENDING BROKEN HEARTS, page 40

Jennifer Kahn's father had a heart attack the day after she was born. He survived—and recently celebrated his 80th birthday. Kahn has had her work selected for the 2003, 2004, and 2005 editions of *Best American Science Writing*.

Robert Clark's most recent story for NATIONAL GEOGRAPHIC was "Blackbeard Lives," in the July 2006 issue.

DESOLATE MAJESTY, page 66

Joe Nick Patoski has been exploring and writing about Big Bend for 25 years. Texas icons still fascinate him; he is at work on a biography of singer and songwriter Willie Nelson.

Jack Dykinga specializes in covering environmental issues in Mexico and the U.S. In 1971 he received the Pulitzer Prize for feature photography.

CURSE OF THE BLACK GOLD, page 88

Tom O'Neill, a senior writer at the GEOGRAPHIC, spent a month in southern Nigeria reporting on the impact of the country's oil industry.

Ed Kashi was held for three days during his work in Nigeria (see On Assignment on the previous page). This is the photographer's 12th project for NATIONAL GEOGRAPHIC. "Struggle of the Kurds," the August 1992 cover story, was his first.

HAWAII'S UNEARTHLY WORMS, page 118

Jennifer S. Holland is a senior writer. She wrote about Central America's red-eyed tree frogs for the November 2006 issue.

Darlyne A. Murawski often trains her camera on small creatures such as insects and spiders. Her latest book, *Face to Face With Caterpillars*, will be published by National Geographic Books in May.

FORESTS OF THE TIDE, page 132

Kennedy Warne inherited a love of the sea; the writer is the grandson of a New Zealand swordfisherman and boatbuilder.

Tim Laman holds a doctorate in rain forest ecology from Harvard University. He spends about half of each year in the field, studying and photographing endangered wildlife and their habitats.

➤ **Tales From the Field** Learn more about our contributors in Features at ngm.com/0702.



Tourists take in a panoramic view of Machu Picchu in Peru.

BEHIND THE SCENES **Geotourism Catches On**

The National Geographic Society's Center for Sustainable Destinations is working to preserve great places by using tourism to help sustain or enhance the places' character, environment, and culture. Honduras was the first to sign the center's geotourism charter; Norway, Romania, and the Cook Islands have followed. With help from National Geographic Maps and local residents, the Center for Sustainable Destinations has already produced map guides of northeastern Vermont, Appalachia, and the Sonoran Desert. Now it is addressing World Heritage sites like Machu Picchu in Peru (above) to rehabilitate the surrounding communities and better involve local people in preservation. To learn more, go to nationalgeographic.com/travel/sustainable.

NG Films

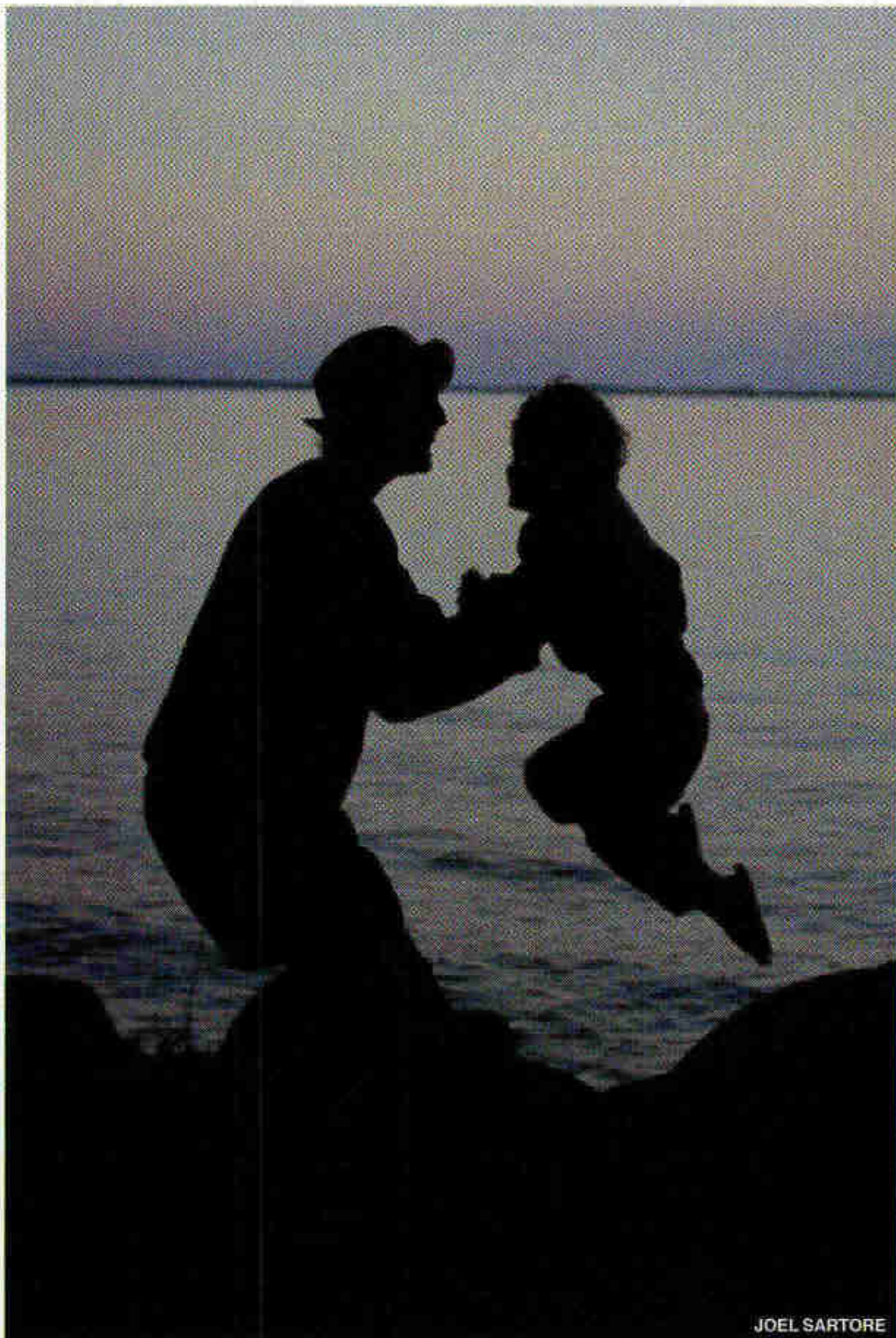
God Grew Tired of Us

Beginning in 1983, roughly 25,000 southern Sudanese boys fled their homes to avoid the government-backed, northern Arab militias terrorizing the region. By 1992 only 10,000 of the boys remained; the rest had died from disease, starvation, and animal attacks during the thousand-mile walk to refugee camps in Ethiopia, then Kenya. Through all their troubles, the remaining "lost boys" of Sudan took care of each other. Against all odds, they stayed optimistic.

In 2001, nearly 4,000 of the boys—now young men—left Africa to make new lives in the United States. *God Grew Tired of Us*, a film by director Christopher Quinn and co-director Tommy Walker, follows three—John Dau, Panther Bior, and Daniel Pach—from the Kakuma refugee camp in Kenya (below) to their new American jobs, schools, and homes.

God Grew Tired of Us, which won the Grand Jury Prize at the Sundance Film Festival, is now in theaters. John Dau's book, *God Grew Tired of Us: A Memoir*, is available in bookstores.





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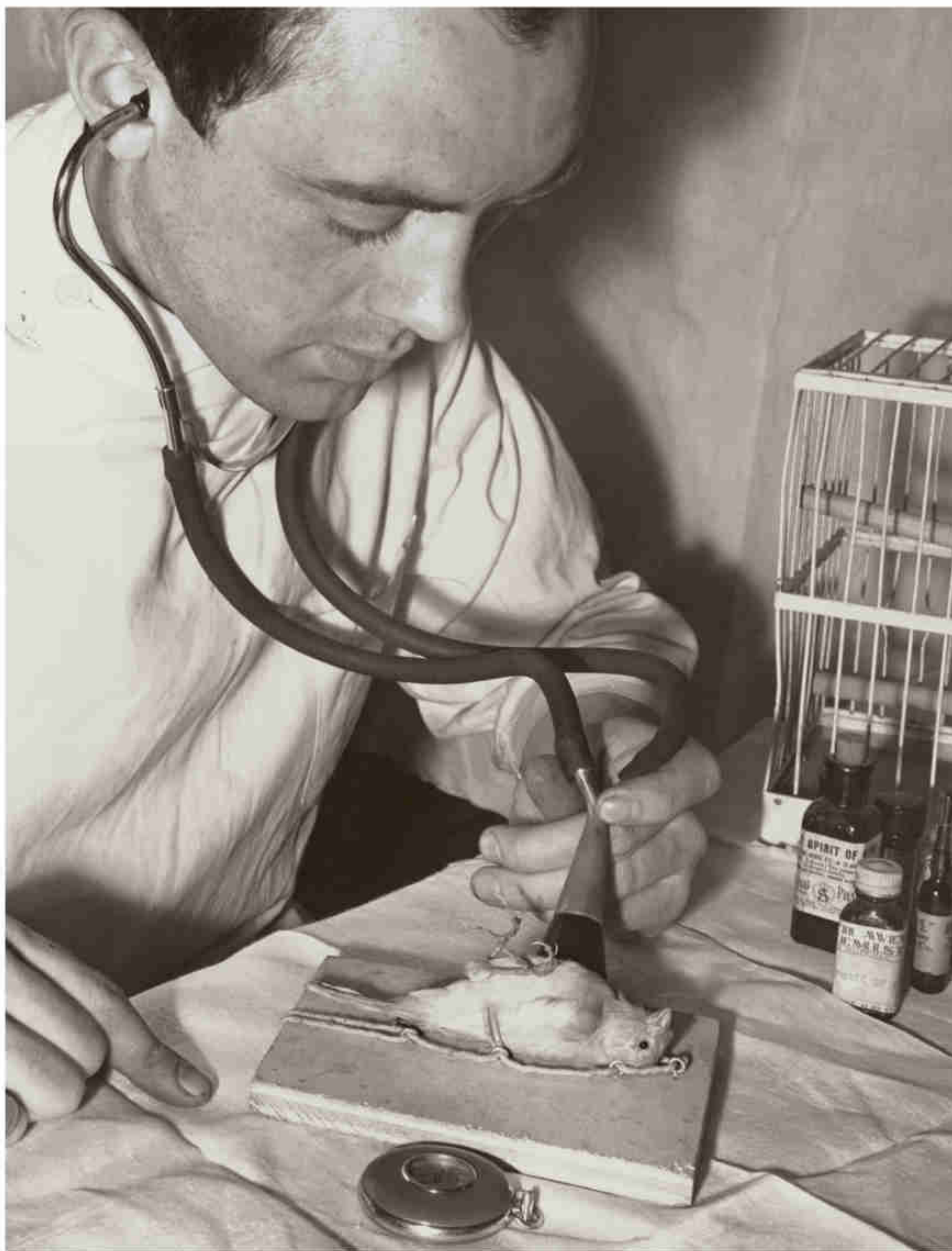
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Canary Care A tiny heartbeat offers an earful to an amateur bird medic named Patrick Lambert. His plywood examination plank held the bird “securely without injury to feathers or other parts,” claim the notes on the back of this photograph, which was acquired by NATIONAL GEOGRAPHIC in 1940 but not published in the magazine. The New Jersey man’s feathered patients ranged “from an inquisitive parrot who walked into an electric fan . . . to a canary blinded by lightning” that “had to be taught to bathe and where to find its seed and water. Not being able to recognize daylight, the bird would often start singing at midnight.” —Margaret G. Zackowitz

👉 **Flashback Archive** See all the photos plus e-greetings at ngm.com/0702.

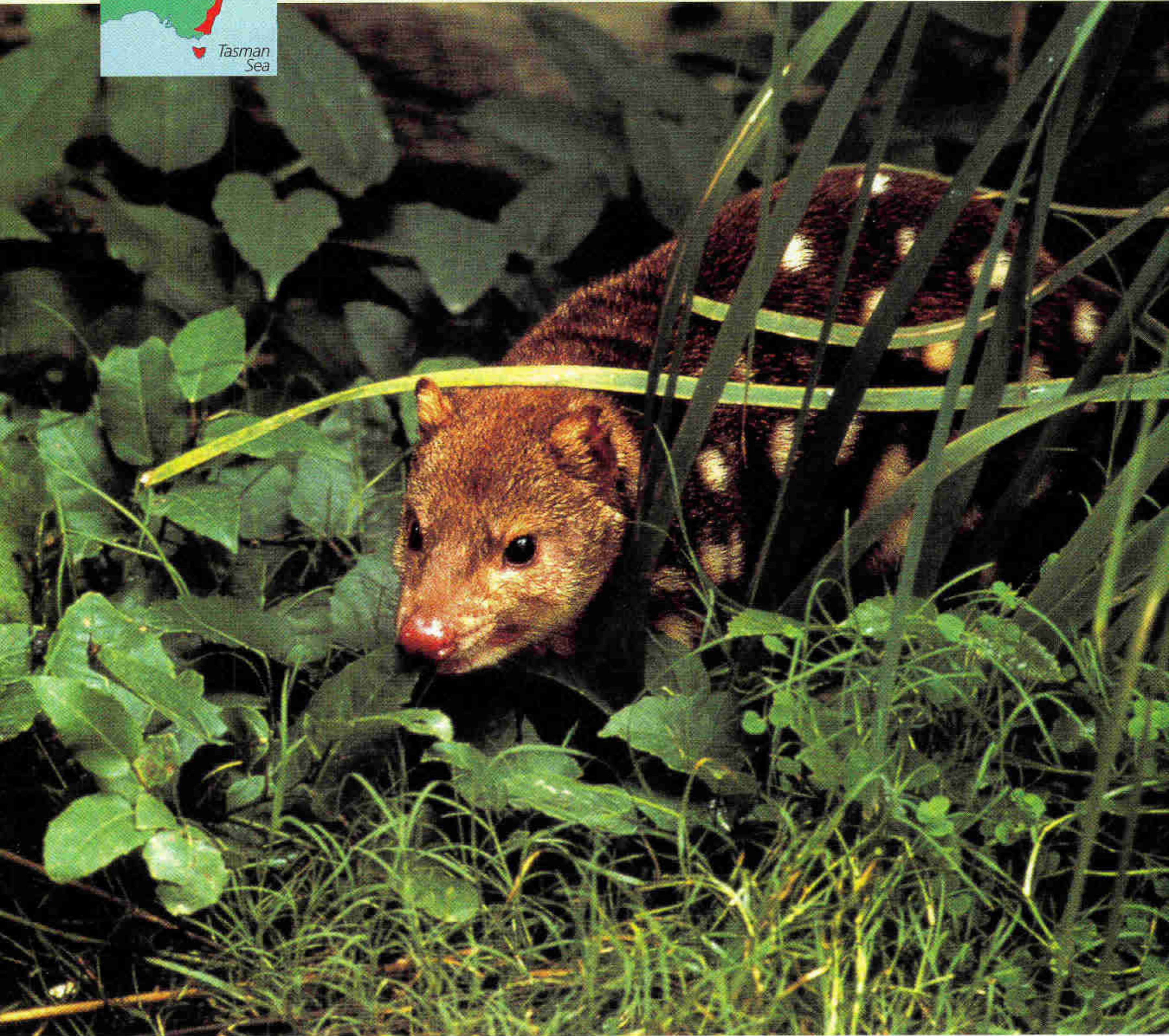
PHOTO: ANDRE LA TERZA



Spotted-tailed Quoll (*Dasyurus maculatus*)

Size: Head and body length, 15 - 21 inches; tail, 13 - 20 inches **Weight:** Males 6 - 16 lbs; females 3 - 9 lbs

Habitat: Sclerophyll forests, woodlands, rainforests, coastal heaths, coastal wet scrub, estuarine areas and rocky headlands **Surviving number:** Estimated at 10,000 - 19,000



Photographed by Erwin & Peggy Bauer

WILDLIFE AS CANON SEES IT

This shadow has sharp teeth. The spotted-tailed quoll—mainland Australia's largest marsupial carnivore—stays largely out of sight during the day, resting in hollow logs or underground dens. Darkness is its element, and it travels great distances in a single night to track down prey. Agile and strong, it makes short work of possums, rabbits and the like. Choice morsels from these nocturnal hunts go back to the den to feed the cubs during their

first four to five months of life. But we may see even less of the next generation; already dangerously small and fragmented, populations are beset by habitat loss and invasive predatory species.

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